Quantized careers : origins and consequences of the preponderance of temporary and junior jobs in academia

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QUANTIZED CAREERS

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CHAPTER 1

Introduction

1.1. Introduction

For countries' economic growth and prosperity, high-quality research and innovation are crucial (e.g., European Commission, 2014). To enable such research and innovation, the governments of several countries have explicitly stated their goals to attract students to science[1] (especially the STEM fields; Maltese, Melki, & Wiebke, 2014). However, during the past decades, opportunities to "move up the career ladder" in science have been increasingly characterized as scarce. The lack of career opportunities, the long spells of employment on temporary contracts, and the dependence on third party funding are seen as major problems in science in the editorials of *Science* and *Nature*, the two leading scientific journals (see *chapter 2* of this dissertation). Critique of the academic career system is not confined to scientific journals, but also appears in popular newspapers and magazines. For example, the final paragraph of a 2010 article in The Economist aptly titled "The disposable academic" says:

> "Many of those who embark on a PhD are the smartest in their class and will have been the best at everything they have done. They will have amassed awards and prizes. As this year's new crop of graduate students bounce into their research, few will be willing to accept that the system they are entering could be designed for the benefit of others, that even hard work and brilliance may well not be enough to succeed, and that they would be better off doing something else. They might use their research skills to look harder at the lot of the disposable academic. Someone should write a thesis about that." ("The disposable academic", 2010)

This is that thesis.

The scientific literature on careers in academic research has focused on different aspects of careers, such as how women are in a disadvantaged position in science, the influence of (international) mobility, and the effects of different modes of research funding. However, one issue has been studied less, namely the career system as such and how it affects the attractiveness of the academic career: how are academic careers built up, what does the typical career ladder look like, which opportunities do those within the system have?

This dissertation will study the topic from various perspectives. First, it describes which issues can be identified in the career system and in academic careers in general. Second, it studies how the career system developed into the system that it is today. Third, the dissertation studies the effects of the academic career system on the attractiveness of an academic career by looking at how they affect job choice and job satisfaction of early career researchers.

[1] In the continental European tradition, throughout this dissertation we will use the term "science" to incorporate all fields, including mathematics, engineering and the humanities.

The title of this dissertation emphasizes that an academic career is not the traditional smooth and linear merit-based progression from student through a junior and subsequent intermediate position to a professorial chair. Instead, careers often consist of many small pieces, or quanta, that are not strongly related to each other and do not necessarily have a clear direction or common content. The uncertainty that in modern physics is the key connotation of the word "quantized", is one of the core phenomena investigated in this dissertation.

1.2. How to define an academic career

Careers have been defined as "the evolving sequence of a person's work experiences over time" (Arthur, Hall, & Lawrence, 1989, p. 8). Careers used to be linear paths of upward mobility in a single organization, in which career advancement was based on tenure: the time in the job (Baruch, 2004). However, since then "protean" (Hall, 1976, pp. 200-203; Hall, 1986, pp. 9-11) or "boundaryless" careers (Arthur & Rousseau, 1996) have emerged, in which control over the career has transferred from the employer to its employees, who develop themselves as they wish and change employers accordingly. With this development, career paths have become multidirectional, both in terms of vertical and horizontal mobility. This also has implications for how career success — "the accomplishment of desirable work-related outcomes at any point in a person's work experiences over time" — should be measured (Arthur, Khapova, & Wilderom, 2005, p. 179). Arthur et al. (2005) distinguish subjective and objective career success. Subjective career success entails an individual's own evaluation of his or her career and is dependent on which aspects of the career are important to that person. In contrast, objective career success is the success that is inferred by the outside world and usually relies on more or less observable attributes, such as rank, salary, number of promotions, etcetera.

Baruch and Hall (2004) argue that careers in academia have had "protean" or "boundaryless" features long before corporate careers attained those features. For example, universities have had relatively flat hierarchical structures compared to businesses and government, academics have enjoyed high levels of autonomy, and career advancement has long been determined by performance instead of time in position, unlike the situation in the corporate and government sector. Still, careers in academia have a feature foreign to protean or boundaryless careers: a rigid hierarchical structure of career ranks.

This hierarchical structure of career ranks differs by country (Baruch & Hall, 2004; Kreckel, Burkhardt, Lenhardt, Pasternack, & Stock, 2008), but typically the highest position is the (full) professorship. The lowest rank depends on whether a system regards those attempting to obtain a PhD degree as academics; if so, these PhD candidates usually make up the group lowest in academic rank. The rigid career structure in academia makes it possible to measure objective career progression through ranks quite easily.

Naturally, from advancement through academic career ranks one cannot infer subjective career success in academia. And, as we shall see later, even though in many countries the academic career structure seems quite clear-cut, the archetypical picture of job titles with increasing rank unduly simplifies the academic career system.

1.3. International comparisons of academic career systems

As indicated above, academic career systems vary by country. To compare shares of female and male academics across ranks, the European Commission distinguishes four grades: "A: The single highest grade/post at which research is normally conducted; B: Researchers working in positions not as senior as top position (A) but more senior than newly qualified PhD holders (ISCED 6); C: The first grade/post into which a newly qualified PhD graduate would normally be recruited; D: Either postgraduate students not yet holding a PhD degree who are engaged as researchers, or researchers working in posts that do not normally require a PhD" (European Commission, 2006, p. 97).

Kreckel et al. (2008) used this classification to show that academic career systems differ heavily between the United States, Germany, France, Great Britain, the Netherlands, Sweden, Austria and Switzerland (Kreckel et al., 2008, p. 352). Among the most notable outcomes is that the share of academics in grade A differs, with United States and France having about a quarter of their academics in this category, whereas this share is only eight per cent for Germany. France, Austria and Switzerland have a large share of academics in the intermediate categories B and C.

This dissertation will focus on academic careers in Germany, the United States and the Netherlands; the choice for these countries will be elaborated upon in the section on the research questions of this dissertation. As background information, an overview of the corresponding ranks in these countries' academic career structure is provided in Table 1. This shows that most positions in one country have an equivalent position in another country.

Table 1. Overview of academic career structure in Germany, the United States and the Netherlands

Grade	Germany	United States	The Netherlands
A	*W3 Professor* (full professor)	Full professor	*Hoogleraar* (full professor)
B	*W2 Professor* (extraordinary professor)	Associate professor	*Universitair hoofddocent* (associate professor)
C	*Juniorprofessor* (junior professor)	Assistant professor	*Universitair docent* (assistant professor)
D	*Wissenschaftlicher Mitarbeiter* (research affiliate)*	Postdoctoral researcher	Postdocs and other scientific staff
D#	*Wissenschaftliche Hilfskraft* (research assistant)	PhD student	*Assistent-in-opleiding* (*AIO*; PhD candidate)

Source: de Goede, Belder, & de Jonge, 2013; Kreckel et al., 2008; Statistisches Bundesamt, 2011. *Not only postdoctoral researchers can be given a position as *wissenschaftlicher Mitarbeiter*, but also PhD candidates. #Only the Dutch *AIO* is actually classified into grade D by the European Commission (2006), as German *wissenschaftliche Hilfskräfte* and U.S. PhD students are not counted as academic employees.

Please note that this picture omits several positions, and that the ranks do not correspond completely. For example, in the United States it is common for assistant professors to be appointed "on a tenure track": the assistant professor is appointed for five to seven years, and is promoted to (tenured) associate professor if proven successful (Fruijtier & Brok, 2007). This implies one can only be appointed as an assistant professor for a limited amount of time. In contrast, in the Netherlands the majority of assistant professors are employed on a permanent contract, and as such can occupy this position until retirement. However, the share of assistant professors employed on a temporary contract is increasing (VSNU, 2015a). One of the reasons for this increase may be that with the growing internationalization of academic research, some universities in the Netherlands have also adopted a tenure track system for its assistant professors (de Goede, Belder, & de Jonge, 2013). This brings us to another issue: whether an academic position comes with tenure (or a permanent contract) or not. In Germany, full and extraordinary professors are usually employed on a permanent contract, although employment on a temporary (or: fixed-term) contract is also possible (Kreckel et al., 2008, p. 45). Junior professors are usually appointed on a temporary contract, as are research affiliates and assistants. In the United States, both full and associate professorships usually imply tenure. As indicated above, assistant professorships are generally tenure track positions. Postdoctoral researchers and PhD students are paid stipends from grants of the faculty member who is their supervisor, or are paid through fellowships (Stephan, 2012, p. 69). Hence, a position as a postdoc or PhD student at a U.S. university is fixed-term. Finally, in the Netherlands, full and associate professors are also generally employed on a permanent contract, whereas postdocs and PhD candidates are virtually always employed on a temporary one. As described above, the majority of assistant professors are employed on a permanent contract, but the last few years have seen a large increase in the share of assistant professors employed on a temporary contract.

In all three studied countries, scientists and other stakeholders have pointed out an increase in temporary contracts at the expense of permanent employment, e.g., in editorials of scientific journals and in general newspapers ("Indentured labour", 2007; Kuiper, 2014; "Op de universiteit stikt het van de flexwerkers", 2013; Piltz, 2015; Powell, 2015), which quite many see as an undesirable development. Indeed, age until tenure in the U.S. has increased (Schuster & Finkelstein, 2006, p. 182). Furthermore, in all countries the number of junior positions has increased more than the number of senior positions (Hill & Einaudi, 2010; Konsortium Bundesbericht Wissenschaftlicher Nachwuchs, 2013, p. 181; Schuster & Finkelstein, 2006: p. 46; VSNU, 2015b). This quantizes the careers of early career researchers: early career researchers are employed on short-term contracts, causing uncertainty and furthering the need to be almost constantly on the lookout for a next job in fierce competition for senior positions.

Such a structure with many junior positions and few senior positions has been compared to a pyramid scheme by Paula Stephan in her 2012 book *How Economics Shapes Science* (Stephan, 2012, pp. 70-71). Although the likening of the academic career structure to an immoral (and often illegal) money-making model seems too strong, such a structure could alter the employment relationship between employer and employee. As a result, the attractiveness of science as a career and the job satisfaction of those within the system may be affected.

1.4. Employment relationships

According to organizational psychology theory, several types of employment relationships exist. Tsui and Wang (2002, p. 78) define the employment relationship as "the formal and informal, the economic, social and psychological connection between an employee and his or her employer". In the same book chapter, they give an overview of several approaches of employment relationship typologies. These typologies generally distinguish a job-focused from an organization-focused approach (as well as mixes of the two). The job-focused employment relationship is characterized by its short-term nature and limited investment from both parties, whereas the organization-focused approach has a long-term nature and much investment from both parties (e.g., by the employer investing in the broad skill development of its employees). Tsui and Wang (2002) argue that a job-focused employment is suitable when the employee is expected to perform specific duties (leading to a "quasi spot" situation), whereas the organization-focused approach is more suited to workers performing open-ended duties (leading to a "mutual investment" situation). Unbalanced situations can also occur, when a job-focused approach is used for workers performing open-ended duties (underinvestment situation) or when an organization-focused approach is used for workers performing specific duties (overinvestment situation). According to Thunnissen (2015, p.

183), talent management at Dutch universities can be characterized as an underinvestment approach, whereas an overinvestment or mutual investment approach would be more suitable for the human resource management of individuals with rare or special skills.

The existence of balanced and unbalanced employment relations is due to the psychological contract that is formed between employers and employees. Rousseau (1995, p. 9) defines the psychological contract as "individual beliefs, shaped by the organization, regarding terms of an exchange between individuals and their organization". If one of the parties experiences a violation in the terms of the contract, it can lead to several consequences. One of these is an exit by the employee (Rousseau, 1995, p. 136), which tends to happen if the employment contract was job-focused. Another consequence is the voicing of complaints, which is likely if there is a positive relationship and channels to voice complaints exist (Rousseau, 1995, pp. 136-138). Still another consequence is silence, which is likely when there are no channels to voice complaints and exit is not an option (i.e., when there are no other job opportunities available). A final consequence is neglect, which includes both "passive negligence" and "active destruction" (Rousseau, 1995, p. 138). Neglect is most likely when there is a history of conflict and when there are no options to voice complaints.

1.5. Attractiveness of science as a career

Following the employment relationship theory, an underinvestment approach should lead to decreased attractiveness of academia as a sector of employment. However, whether career opportunities in academia and the likelihood of a tenured position influence the attractiveness of science as a career, is a debated issue. On the one hand, it is argued that despite poor career prospects, there is no shortage of talent in science, but rather a "war between talents", in which there is an oversupply of talents in relation to the career opportunities available (van Arensbergen, 2014, p. 121). On the other hand, in the early 2000s both Huisman, de Weert and Bartelse (2002) and van Vucht Tijssen (2000) argued that dwindling career opportunities decrease the attractiveness of faculty positions. However, looking at studies on the career preferences of PhD students, the supposedly limited academic career opportunities have not affected the attractiveness of academic careers to a large extent. That is to say, although these studies have not correlated career opportunities with career preferences, most find that academia is the most attractive sector of employment (Fox & Stephan, 2001; Roach & Sauermann, 2010; Sauermann & Roach, 2012 for the U.S.; Bloch, Krogh Graversen, & Skovgaard Pedersen, 2015 for Denmark; Gemme & Gingras, 2012 for Québec; Conti & Visentin, 2015 for Sweden and Switzerland). Postdoctoral researchers exhibit an even stronger preference for employment in academia (Puljak & Sharif, 2009 for the U.S.; Fitzenberger & Schulze, 2014 for Germany; van der Weijden, Teelken, de Boer, & Drost, 2016 for the Netherlands).

That is not to say that non-academic sectors are not appealing to PhD students and postdoctoral researchers. Their appeal varies by field of PhD. For example, for U.S. chemistry PhD students working in industry is more appealing than for PhD students in other fields (Fox & Stephan, 2001; Sauermann & Roach, 2012). In Denmark, a relatively high share of PhDs from the medical and health sciences works in the public sector, as many of these PhDs work in hospitals or other medical organizations (Bloch et al., 2015).

According to the sociology of science, one of the purposes of doctoral education is the socialization of PhD students into the academic profession (Gardner, 2007; Larivière, 2012). Turner and Thompson (1993) describe doctoral education as "a lengthy period of adult socialization in cognitive skills, appropriate attitudes toward research and scholarship, and field-specific values" (p. 357). A wide range of activities are included, such as meetings with supervisors and peers, writing scientific works and publishing these. Studies into organizational socialization have shown that it increases organizational commitment and decreases turnover intention (i.e., the intention to leave a company or organization; Bigliardi, Petroni & Dormio, 2005; Vazifehdust & Khosrozadeh, 2014). Indeed, in 1965 Warren O. Hagstrom described how socialization "effectively isolates [graduate students] from competing vocational and intellectual interests and (…) [makes them] extremely dependent on [their] teachers" (Hagstrom, 1965, p. 9).

Hence, socialization plays an important role in shaping the career aspirations of young academics. Here, psychological contract theory linked to the process of socialization may be illuminating. Academia is said to offer a greater degree of independence and academic freedom, and researchers in academia value these attributes (Roach & Sauermann, 2010). In contrast, pecuniary rewards and other employment conditions are valued less by many academic researchers. Socialization into academia with its valuation of academic freedom and independence rather than employment conditions may make early career researchers accept relatively poor career prospects in academia more readily than they would otherwise. Said differently: the psychological contract between an early career researcher in academia and their employer may not include the expectation of job security, as the early career researchers have been socialized into expecting long periods of temporary employment. In this situation, unbalanced employment relationships need not lead to dissatisfaction, complains or neglect. This, however, does not mean that early career researchers will stop comparing career opportunities and look for a more advantageous employment relationship elsewhere. Then the perception of career opportunities may influence career preferences and the actual sector of employment. Whether it indeed does, and if so, to what extent, is a question not answered yet.

1.6. Job satisfaction of PhD graduates and academics

A subjective measure of career success that is used in several studies is job satisfaction (Arthur et al., 2005). Locke (1969, p. 316) defined it as "the pleasurable emotional state resulting from the appraisal of one's job as achieving or facilitating the achievement of one's job values". In their theoretical discourse on the employment relationship, Tsui and Wang (2002, p. 107) proposed that the type of employment relationship influences (job) satisfaction. In this way, the underinvestment approach that universities employ in their talent management, which is characterized by a lack of opportunities for career advancement and job security, decreases employee well-being (Thunnissen, 2015, pp. 182-183).[2]

Academics tend to be quite satisfied with their job (e.g., Boyer, Altbach, & Whitelaw, 1994; Lacy & Sheehan, 1997). In an international survey among academics from fourteen countries, Boyer et al. (1994) found that these academics were satisfied with the intellectual aspects of their jobs, the relationship with their colleagues, and the courses they teach. They were less satisfied with their salary and with the way the university is led by top administrators. Lacy and Sheehan (1997) found that professors were most satisfied with the opportunity to pursue their own ideas, the courses they taught, the relationships with colleagues, and the job situation as a whole. These professors were (much) less satisfied with the way the institution is managed and with their prospects for promotion.

In addition, multiple studies on the job satisfaction of PhD graduates have been performed, in several countries (e.g., Bender & Heywood, 2006; Di Paolo, 2016; Kifle & Desta, 2012; Moguérou, 2002). In the U.S., PhDs in academic employment are more satisfied with their jobs than PhDs in non-academic employment (Bender & Heywood, 2006; Moguérou, 2002). Both studies also found female PhDs to be less satisfied than male PhDs. PhDs from Catalonia who work in non-academic sectors are less satisfied with job content, but more satisfied with their earnings than PhDs in academia (Di Paolo, 2016). These studies show that job satisfaction among academics and PhD graduates is multi-faceted with regards to both the job qualities they are satisfied with and the factors that influence satisfaction: academics and PhDs may be satisfied with their salary, but not with their colleagues, for example. And working outside academia may have a positive effect on satisfaction with salary, but have no effect at all on satisfaction with colleagues. This is important to bear in mind when studying the effect of employment conditions on job satisfaction.

[2] Please note that Thunnissen found that "[talented academics] want job security in terms of employability […]: rather than employment, they want the certainty that they can continue to develop as an academic and pursue an academic career in which the abovementioned non-economic job orientations (meaningful, challenging work, autonomy, etc.) are key aspects […]. " (Thunnissen, 2015, p. 182).

1.7. Research questions

As announced in the introductory section, the aim of this dissertation is to study the academic career system by describing its development through time and study its effects on job choice and job satisfaction.

However, the policy field of academic careers is large and encompasses a wide range of topics. Therefore, first the field of academic career policy was mapped and its key issues identified. Accordingly, the first main research question of this dissertation is:

1. What are the key topics discussed in *Science* and *Nature* editorials relating to academic career policy?

In *Science*, the authors of these editorials are the editor-in-chief (a distinguished scientist usually at the final stages of their career) or guest writers, who are usually high level policymakers in the field of science. In *Nature*, the editorials are written more journalistically: they are written by (anonymous) editors of *Nature*, who are often PhD-holding science journalists whose goal is to spot breakthrough research and offer reflection on scientific developments and science policy (van Calmthout, 2016). Analyzing the editorials of *Science* and *Nature* therefore gives a good overview of the keys issues in academic career policy. The other studies in this dissertation go into three key issues identified by *Nature* and *Science* editorials: career conditions in science, the attractiveness of science as a career, and the role of gender in academic careers. The editorial analysis and other data available on academic career prospects tentatively sketch a picture in which career prospects have indeed worsened and temporary employment has increased. Since a more thorough historical analysis is lacking in the literature, the second main research question of this dissertation is:

2. Historically, how has the composition of academic positions changed in Germany and how has the span of publication careers of PhD recipients from the United States changed (both before and after the PhD)?

As described in the earlier section 1.3, the composition of academic staff in several countries has shifted from senior to more junior staff (e.g., Schuster & Finkelstein, 2006). However, most of the literature is restricted to the second half of the 20th century and the early 21st century, and does not take into account historical developments that led to the emergence of specific positions. Data on the extent of temporary employment are often lacking, too.

Therefore, *chapter 3* describes the development of the structure of academic careers in Germany from the 19th century to the present day. Germany was chosen as the country of study, as the concept of the research university originated there. The German data show large changes in the structure of academic careers over the past two centuries, with the last quarter of the 20th century showing vast increases in the number of (temporary) research affiliate positions. Thus it would be natural to presume that the pattern of publication careers has also changed. As stable jobs have given way to short-term jobs, and only a small share of academics in such short-term jobs will eventually land a stable job (e.g., Ioannidis, Boyack, & Klavans, 2014; Stephan, 2012, p. 170), the spell during which academics publish their work would seem likely to have shortened as well. However, whether this presumption is correct needs to be verified. We do so for the U.S., as the U.S. has been the dominant nation in science since the mid-20th century, the period for which publication careers can be most readily measured.

More specifically, *chapter 4* describes trends in the length of publication careers of U.S. PhD graduates since the 1950s. This is achieved by matching the names of a subset of PhDs (i.e., those with rare names) in astrophysics, chemistry, economics, genetics and psychology in the dissertation database ProQuest, to the database of scientific articles Web of Science. The ProQuest database is the highest quality database of doctoral dissertations, but high-quality coverage is limited to North America.

Finally, if career prospects have indeed worsened and employment conditions in academia have deteriorated, as much of the scientific literature on the topic suggests, it raises the question to what extent these issues do or do not affect those in the system. This leads to the third research question of this dissertation:

3. What are the effects of career prospects and employment conditions on early career researchers in the Netherlands?

This question focuses on the consequences of quantization for the researchers and on the effects of its associated uncertainty in the Netherlands, as high quality data collection on this topic was possible from our position. Moreover, the Netherlands has a standardized academic career system and quite uniform HRM policies in its universities (de Goede et al., 2013). The Netherlands also has the largest share of PhD graduates working outside higher education among the OECD countries (Auriol, Misu, & Freeman, 2013, p. 19), which means that there is a large diversity in the careers of early career researchers and probably also in their considerations when pursuing a career. Finally, and most importantly, Dutch universities uniformly produce good research – by most accounts, they are no elite universities but the research performed in all universities is of good quality. Therefore, by surveying a group of recent PhDs from five Dutch universities encompassing all scientific disciplines, we are able to study the effects of career prospects and employment conditions in a representative group of PhDs from all Dutch universities. In contrast, if PhDs from the United States had been surveyed, the status and quality of the PhD-granting institutions would have varied much more if universities had been picked from the pool of all universities. More information could have been obtained on the consequences of quantization for PhDs from elite institutions, but also PhDs from institutions with much less status would have been studied, and this variability should have been taken into account. By surveying PhDs from Dutch universities, one obtains a better picture of the consequences of quantization for the group of good but perhaps not elite researchers – a group important for the knowledge economy (OECD, 1996).

The question is divided into sub-questions, by chapter. In section 1.5 we discussed that many factors influence the career preferences and actual employment of PhDs. However, whether their perception of career prospects is correlated with their sector of employment, is an unanswered question. This question is especially pressing in the case of recent PhD graduates, as they have changed jobs after completing their PhD.[3] Therefore, the research question of *chapter 5* is:

a. How are career prospects in academia and other sectors perceived by recent PhDs from Dutch universities, and how is this perception related to their job choices?

Another key issue in academic careers are employment conditions. Temporary employment has long been prevalent in academia but is becoming increasingly common in other sectors, too. According to dual labor market theory, temporary jobs are "bad jobs" that are not only sub-par to permanent jobs with respect to employment conditions, but also have poorer job content. However, some subgroups, e.g., the young, and the highly educated, may be exempt from these negative effects. As recent PhDs are both highly educated and (often) young, they may be a case in point. On the other hand, postdoctoral researchers report high levels of career insecurity due to temporary employment (e.g., Höge, Brucculeri, & Iwanowa, 2012; van der Weijden et al., 2016). Almost by definition, though, postdoctoral researchers have a temporary contract and thus, such studies cannot determine the effect of temporary employment by comparison to a control group. To study the effect of temporary employment, we therefore included PhDs on several types of contracts in our study. *Chapter 6* assesses:

[3] This is the case for most PhDs in the Netherlands. PhD candidates appointed by a university are employed on a fixed-term contract reserved for PhD candidates. Thereby, by definition they will have had to have changed jobs after PhD graduation. However, there is also a sizeable group of PhD candidates who are not appointed by a university: "external" PhD candidates. Among them are PhD candidates employed and paid by another organization. These PhD candidates may still have the same job after obtaining their PhD. Still, most PhD graduates will have changed jobs after obtaining the PhD.

b. What is the effect of temporary employment on the job satisfaction and personal lives of recent PhDs from Dutch universities?

Another issue in employment conditions concerns the type of appointment of PhD candidates. Among academics at U.S. universities, wage inequality was shown to decrease the job satisfaction of those earning below the median (Card, Mas, Moretti, & Saez, 2010). This raises the question what the effect of the labor market status of PhD candidates is on their PhD experience. In many countries PhD candidates are formally treated as students, but in the Netherlands, approximately half of the PhD candidates are employed by a university (European University Association, 2007, p. 29). Since the other half of PhD candidates in the Netherlands are *not* employed by a university, there is enough variation in labor market terms to analyze the effect of labor market status. Therefore, *chapter 7* investigates:

c. What is the effect of appointment type on the availability of research infrastructure, work pressure, stress, and career attitudes of PhD candidates at a Dutch university?

A third important issue is the mediating role of gender in the effect of career prospects and employment conditions on early career researchers. Many studies have looked into the role of gender *within* academia, for example in how it plays a role in job activities, academic promotion and scientific accomplishments (e.g., Bellas & Toutkoushian, 1999; Ceci & Williams, 2011; Kaminski & Geisler, 2012; Larivière, Vignola-Gagné, Villeneuve, Gélinas, & Gingras, 2011; Ward, 2001). In comparison, considerably less attention has been paid to gender differences within the group of all PhD graduates, including those *not* working in academia. This is regrettable, as it limits knowledge on gender differences within the highest educated group in society and may bias the picture. To fill this gap, *chapter 8* investigates:

d. What is the effect of gender on the type of employment, occupation, career perception and research performance of recent PhDs from Dutch universities?

Together, the answers to the research questions describe which issues are the most pressing in academic career policy, how the career system developed into the system that it is today, and what its effects are on publication careers, the job choice and job satisfaction of early career researchers.

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PART I

Delineation of key topics in academic career policy

CHAPTER 2

Careers in science: Policy issues according to *Nature* and *Science* editorials

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Abstract

This study analyzes the editorials in *Science* and *Nature* published between 2000 and 2012 about careers in science. Of the total body of documents, 8.8% dealt with science careers. The editorials were manually classified by topics and then mapped using the VOSviewer. This revealed six easily distinguishable clusters: career conditions in science, the attractiveness of science as a career, merit-based career policies, the effect of research funding on careers, specific groups underrepresented in science, and mobility of scientists. The paper summarizes the main thrust of the arguments in these editorials. There is strong agreement about the problems in scientific careers, but less consensus on the solutions to these problems. The paper also explores whether mapping on the basis of automatically identified terms could have provided adequate results, but concludes that manual classification is needed.

2.1. Introduction

In science, quality is intimately connected to the ingenuity, creativity and persistence of its practitioners. Therefore, a high-quality research system has a vital need to attract and retain the most talented scientists. In the past years difficulties in pursuing an academic career have been noted by researchers, journalists, and governments alike (Commission of the European Communities, 2003; National Research Council, 2005; Rice, 2012; Schiermeier, 2004; van Balen & van den Besselaar, 2007; Zimmer, 2012). Research into academic careers encompasses various issues: career determinants, mobility, and gender, to name just a few (Ceci & Williams, 2011; Jonkers, 2011; Kaminski & Geisler, 2012; Levin & Stephan, 1999; Timmers, Willemsen, & Tijdens, 2010). However, to our knowledge no literature exists on which issues in academic careers are considered the most important ones by main actors in academic career policy, i.e., opinion leaders in science. In this study our aim was to answer this question.

To this end we analyzed the contents of editorials from *Science* and *Nature*. These are the world's most widely read and authoritative multidisciplinary scientific journals. *Science* is a publication of the American Association of the Advancement of Science, which is a general-science learned society, whereas *Nature* is published by the British Nature Publishing Group, an independent commercial publisher. In addition to research papers "from all fields of science and from any source" ("*Science*: Information for authors", 2012) and "from any area of science with great potential impact" ("About Nature Publishing Group journals", 2012), *Science* and *Nature* publish other sections of general interest to scientists, e.g., news, book reviews, and opinion pieces. The main opinion pieces are editorial material written by the editors or invited writers. The editorials of *Nature* are written by unnamed editors, who are typically PhD-holding scientists who have pursued a career in science journalism and publishing. Conversely, editorials in *Science* display the name of the author, which is either the editor-in-chief or a guest writer. The editor-in-chief is a distinguished scientist who has taken up the job of editor-in-chief of *Science* after a long career in science. Guest writers are usually policy makers in the field of science, including science ministers or persons occupying comparable posts. Thereby, analyzing the editorials of *Science* and *Nature* gives a varied overview of the opinion of different policy makers and opinion leaders in science. The high global impact and visibility of *Science* and *Nature*, not just in scientific research but also in research and science policy, as well as the nature of the editorial writers, virtually guarantee that the content of the editorials does not merely reflect the specific perspective of practicing researchers, but also that of the leaders of major scientific institutions, science media and policy makers at both national and international levels (unlike editorials from other scientific journals, which tend to focus on scientific developments). With this in mind, it seems fair to describe the editorials as an authoritative indication of the views of opinion leaders in the global science community.

The editorials are concerned with a range of current topics on the boundary between science and policy (Waaijer, van Bochove, & van Eck, 2010; Waaijer, van Bochove, & van Eck, 2011). Over the past decade, a significant number of these editorials concerned careers in science. Classifying these particular editorials thus provides information on the main concerns of these global science opinion leaders in the field of research careers.

2.2. Data and methods

2.2.1. Data

Nature and *Science* editorials published between January 2000 and January 2012 were collected in html format. 'World View' opinion pieces from *Nature*, which are written by invited scientists and policy makers across the globe (published September 2010 – January 2012) were also included in the sample set since they have a scope that is similar to the editorials and are directed at the same general audience as the editorials. *Nature* also publishes columns and features on scientific careers in a designated section ("Naturejobs" from 2000 until September 2010 and "Career" from September 2010 onwards). This section is connected to the service *Naturejobs*. The columns and brief essays in this section have not been included, since they are clearly part of a special niche rather than being directed at a general audience. Including this niche would overstate the relative importance of scientific careers in the total editorialization of *Nature*. The html files were processed in such a way that only titles and body text remained.

We have selected the editorials concerning career policy on the basis of the occurrence of terms considered to be indicative of this subject (cf. Table S1 in appendix 1 for the precise list of terms). The main goal was not to miss any editorials concerning careers; hence the terms used were quite broad. Using this method 326 editorials (out of a total of 2151) were selected.

Below we will conclude that a substantial part of these 326 editorials do not actually concern careers, but are about completely different subjects. Therefore, we determined whether the selection of editorials according to terms occurring in the texts could have benefited from the omittance of certain terms during selection. This revealed that some terms were redundant for selection (Table S2 in appendix 1), but omitting them would not have led to a smaller number of non-relevant editorials either. No other terms used for selection could have been omitted without losing relevant editorials.

2.2.2. Document map on the basis of manual classification

In order to analyze the contents of the editorials, the editorials were manually classified by subject. The subject descriptions are shown in Table 1. Each editorial is described by one or more subject names. In addition, the extent to which scientific careers actually were the subject of the 326 originally selected editorials was determined. To this end, the editorials were separated into three groups: scientific careers as main subject, scientific careers as one of multiple subjects, and scientific careers not a subject. All editorials with scientific careers as their subject or one of their subjects were selected, adding to a total of 190 out of the original 326 editorials. A document map, which shows the similarity and dissimilarity of documents within a set, was made. For this map a 'co-subject' matrix was constructed. Thus, two editorials that are about 'women' and 'minorities' have a higher number of subjects in common in the matrix than two editorials with 'women' and 'mobility', and 'women' and 'salary', as their subjects, respectively. The clustering method is a weighted variant of modularity-based clustering (Waltman, van Eck, & Noyons, 2010). Using the editorials' subjects the similarities between editorials were determined by calculating the association strength measure (van Eck & Waltman, 2009). The VOS mapping technique was then applied to the association strengths to yield a two-dimensional map of the editorials (van Eck, Waltman, Dekker, & van den Berg, 2010). Finally, the two-dimensional map of the clusters of editorials was visualized using the VOSviewer (van Eck & Waltman, 2010).

2.2.3. Document map by automatically identified common terms

We also applied document mapping on the basis of automatic term identification, in order to analyze whether this would approximate the clustering on the basis of manual classification. The same technique as mentioned above was used, but in this case mapping was based on common automatically identified terms instead of common manually determined subjects. Terms in the editorials were identified by matching them against the OpenNLP library (http://opennlp.apache.org/), which parses noun phrases from texts. Then, the specificity of the terms was determined by calculating their Kullbeck-Leibler distance (van Eck & Waltman, 2011). Parameters (binary/full counting, threshold of occurrences and percentage of most specific terms) were varied and the parameters yielding the best term map were determined.

Table 1. Subject name descriptions

Human resource management in science	
Career perspectives	Perceived number of available (higher) academic positions
Promotion criteria	Criteria on which researchers are promoted to a higher position
Mobility	Extent to which researchers are willing and able to move between countries, institutions etc.
Independence	Ability to pursue own research ideas
Tenure	Permanent academic position
Salary	Remuneration of scientists
Attractiveness	Extent to which a career in science is viewed as desirable
PhD students	Persons working to obtain a PhD or equivalent academic degree
Postdocs	Postdoctoral fellows (PhD graduates typically on a fixed-term contract)
Habilitation	Second academic degree after PhD
Minorities	Groups underrepresented in science (not including women)
Women	Position of women in science
Mentoring	Advisory relationship between experienced and less experienced researcher
Age	Age-specific issues in science career policy
Retirement	Policies concerning scientists' retirements
Creativity	Ability to invent and pursue original scientific ideas
General policy and politics	
Science policy	Regulations that optimize science output (funding, organizational structure etc.) in order to pursue policy goals
Priority setting	Determination of relative value of research (fields, types of research, types of researchers) and consequently where funding should be allocated (subfield of science policy)
Competitive recruitment	Amount of competition needed to leave the best researchers in the system (subfield of science policy)
Politics	Principles that inform government policy
Other	
Peer review	Self-regulation of scientific quality
Education	(Science) teaching of students at all levels (primary school, secondary school, college, university) and teaching of general public
Scientific misconduct	Violation of good research practices
NES	Not elsewhere specified

2.3. Results and discussion

2.3.1. Topics in academic career policy

The manual determination whether scientific careers were a subject in the selected editorials showed that 113 editorials had academic careers as their main subject, 77 had academic careers as one of several subjects, and 136 did not have academic careers as their subject. This means 5.3% of all *Science* and *Nature* editorials were mainly concerned with scientific careers, and that another 3.6% had careers as one of several subjects, the total share of editorials to deal with scientific careers thus amounting to 8.8%.

The manual classification showed that the editorials discussed many different topics within the field of academic careers. Table 2 shows how frequently each topic occurred. The most frequent topics were science policy (43.7%), mobility (21.1%), attractiveness (20.5%), career perspectives (16.8%), women (16.5%), promotion criteria (14.7%), education (13.7%), and independence (10%). However, more than one topic can be discussed in one editorial, and some topics might be correlated. In order to obtain an overview of all editorials at a glance, the document map on the basis of our manual classification as described above was used to cluster the editorials into larger groups. The constructed map distinguishes six different clusters, which we will refer to as 'main groups' (Fig. 1). In general, editorials at the edges of the map are only related content-wise to other editorials in that area of the map, which means they are relatively specific in their subject matter. On the other hand, editorials positioned at the centre of the map have topics in common with editorials from other main groups as well. The map can be examined in more detail at www.vosviewer.com/maps/careereditorials.

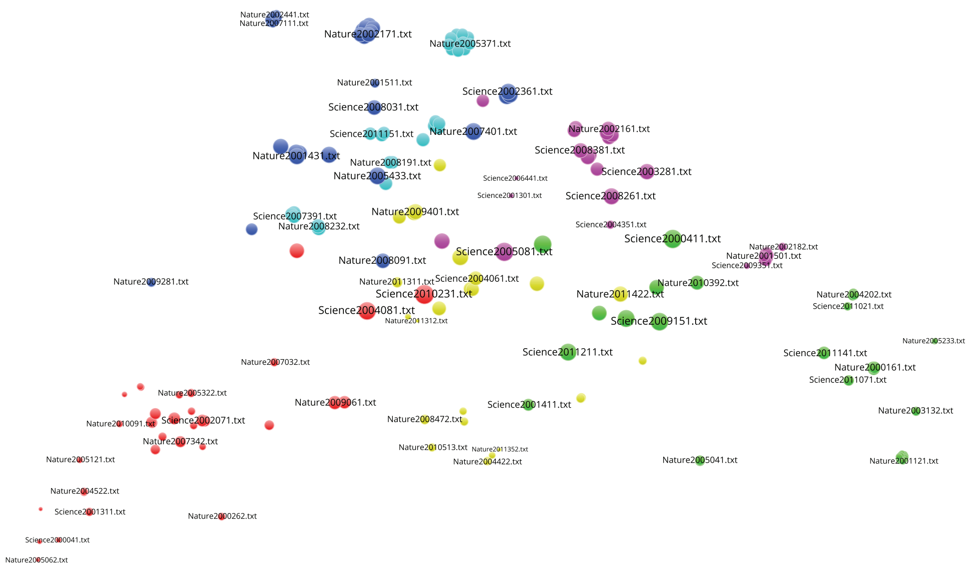

Figure 1. VOS map of career-related editorials (career as main subject or one of several subjects) on the basis of manual topic assignment; clustering by weighted modularity-based clustering (size of circles represents number of topics assigned to editorial)

Table 2. Topics in scientific careers, as % of number editorials with keyword as subject or one of subjects, divided by the total number of editorials

Topic	*% of total number of relevant editorials*
Science policy	43.7
Mobility	21.1
Attractiveness	20.5
Career perspectives	16.8
Women	16.3
Promotion criteria	14.7
Education	13.7
Independence	10.0
Minorities	8.4
Postdocs	7.9
Tenure	7.4
Competitive recruitment	6.8
PhD students	5.8
Age	4.7
Salary	4.7
Scientific misconduct	4.7
Peer review	4.2
Politics	3.7
Mentoring	3.2
Priority setting	3.2
Creativity	1.6
Habilitation	1.1
Retirement	1.1
NES	1.6

The first and largest main group (in red) deals with *conditions* for careers in science. Most opinion pieces in this group are concerned about a lack of career perspectives for young scientists. Many editorials note that this situation has led to longer postdoctoral periods; consequently, the period until researchers can pursue their own research lines has increased. This situation needs to change according to multiple editorials, and initiatives promoting early career independence are praised. Some editorials also argue that the increased period until independence is stifling innovative and creative research. Another worry is that the current difficulties in academic careers make science less attractive to prospective entrants. However, a few editorials (from both *Science* and *Nature*) make the case that faculty members and science as a whole might actually *benefit* from a system with a shortage of faculty positions, because it keeps labor costs of a well-trained workforce at a low level. Within the red main group there also is a small number that does not deal with career conditions as such, but with scientific misconduct, and more specifically with the causes of scientific misconduct. Authors of these editorials see the competitive system of science (e.g., for funding, appointments, and tenure) as a factor that may promote scientific misconduct.

The second main group of editorials (in pink) treats the *attractiveness* of science as a career, especially as a future prospect. The editorials strongly emphasize the need for high-quality education, particularly in STEM fields, to stir up students' enthusiasm for science. A number of pieces applaud outreach initiatives to the general public, which they mark as good methods to increase interest in science and show its benefits. Although this group of editorials mainly deals with the attractiveness of a career *in* science, a few editorials actually recommend graduates with a scientific background to make their education and way of thinking useful to other fields and pursue careers such areas as education and policy.

The third main group of editorials (in yellow) focuses on *merit*-based career policies, mainly dealing with the question which factors and characteristics should be important in hiring, promotion, and tenure processes. Quite a number are concerned with countries where authors feel scientists are not promoted on the basis of their scientific credentials, but rather on more diffuse grounds. Other editorials argue that scientists should not be judged only on their research output in the form of journal articles, but also on their teaching excellence, writing books, or outreach to the general public. In relation to this subject, one of the editorials questions the use of journal impact factors as a measure of the scientific quality of papers, and argues that they should not be used for promotion processes. This main group of editorials also includes some that address the increasingly distrustful attitude towards science of (American) politicians, and the barriers for research into "sensitive" topics politicians have raised on non-scientific grounds. They argue that this development has damaged the careers of researchers working in these fields.

The fourth main group (in turquoise) covers the effect of research *funding* on scientific careers. A number deal with how researchers' opportunities for a career in science are influenced by the amount of resources available to research. Priority setting and its effect on careers are also important: editorials within this group discuss the effect of the allocation of funding to specific subjects on the careers of the researchers working in these fields and even more on the careers of those *not* working in these fields. Furthermore, a few editorials discuss which types of research and consequently whose careers should be supported. The prevailing opinion is that ground-breaking, innovative projects by young researchers should receive more funding, usually through personal grants. Surprisingly, the sentiment that resources should be given to researchers that have established themselves as excellent researchers was expressed to a much smaller extent. Nevertheless, the first editorial of the millennium in *Nature* advocated block funding for excellent researchers as a means to drive innovative research; without it, the author says, the laser would never have been invented. Like the main group on the attractiveness of science as a career, the funding cluster also contains a few editorials encouraging scientists to take up careers in policy, emphasizing the importance of having more people with scientific backgrounds in policymaking.

The fifth main group (in green) is concerned with *specific groups* in science. Mainly, this group deals with the lack of representation of women, racial minorities, and disabled persons in science. Over 80% of the editorials in this group touch upon the underrepresentation of women. The editorials do not only state the problem, but also propose causes of the underrepresentation, like attitude towards women (often subconscious) and gender bias in the promotion system.[1] Many measures are put forward to improve the position of women in science. A much smaller number of editorials deal with the position of minorities in science and measures to improve their number. A remarkable case put forward in a few editorials is South Africa, where a minority of the general population (white people) actually form a majority in science, and the majority in the general population are underrepresented in science and should be encouraged to pursue a career in it.

The final main group (in dark blue) contains editorials on the *mobility* of scientists. The prevailing opinion is that mobility between institutes, preferably internationally, should be encouraged. A few editorials explicitly say specific countries should become more attractive for foreign researchers (e.g., France, Spain, Russia, Germany and Japan). Other editorials call for unity in research systems and career structures among the different countries of the EU. Furthermore, an important category of opinion pieces is concerned with the international barriers put up by the U.S. after the 9/11 attacks. Authors of editorials feel these barriers to international scientists are unjust and are actually damaging American science, because the United States is increasingly dependent on foreign scientists to fill its PhD student and postdoc demand. Finally, the importance of mobility for countries not at the scientific front is highlighted: the scientific standard of these countries can be improved through their scientists training in top science countries, provided the scientists are eventually repatriated.

Our results show that the opinion leaders writing editorials often do not treat issues in academic career policy as if they were isolated topics by writing about only one issue. Rather, they write about multiple connected issues, e.g., the lack of career perspectives being especially pressing for PhD students and postdocs, and women and racial minorities both being underrepresented groups in science etc. However, the map of the editorials also shows

[1] A disproportionate number of editorials on women in science (almost 1 in 5) are especially concerned with the position of women scientists in Japan. As editorials on this subject only appeared in *Nature*, we suspect the influence a single editor here.

that the main groups are not perfectly separated groups, but are actually interlocked (Fig. 1). One example of the latter is that good education of students and outreach to the public are considered to be important for the attractiveness of science, and should also be rewarded in promotion procedures. Another example connects funding to mobility: several editorials say that more funding should be allocated to hiring foreign scientists in countries with low international mobility.

Academic career systems vary considerably throughout the world (Kreckel, Burkhardt, Lenhardt, Pasternack, & Stock, 2008). One might expect that the main groups of topics identified would therefore be nation-specific or continent-specific. However, the key topics of our main groups were described as a problem in countries across the globe. For example, a lack of career perspectives is felt in the United States, Europe, and Asia alike. The fear that science might not be sufficiently attractive is present even in a developing country such as India, where policy makers feel "banking, business, and information technology have become immensely popular", more so than science and engineering. A few topics within the main groups are more specific to certain countries, however. The issue within the main group of merit-based career policy of political connections playing a more important role than academic credentials is identified in former Soviet, Mediterranean, and Asian countries, but not in Anglo-Saxon countries. And not surprisingly, the issue of mobility of scientists is described differently in editorials depending on the perspective: the perspective of countries with a net influx of scientists, and the perspective of countries which have scientists leaving and hoping they will return to help improve the science system in their native country.

2.3.2. Mapping by automatically identified terms

Manual classification is usually informative and correct, apart from occasional reading errors or subjective decisions in assignment to subjects. The main drawback is its laboriousness. In our case of 326 fairly short texts this was not a major drawback, but with a large body of literature it would have been. Therefore, it is worthwhile to investigate whether similar results could have been obtained with fully computerized data processing techniques. Note that since we want an automated approach to emulate the manual one, we must here map all 326 editorials, including the ones that are not relevant according to the manual procedure. To map the documents by common terms, we first needed to automatically identify the most meaningful terms in the documents. To this end, term maps were constructed by varying parameters (full counting/binary counting, threshold for number of occurrences, and threshold for relevance). The best term selection was obtained by full counting and a threshold of 10 occurrences, of which the 70% terms with the highest termhood were selected (Table S3 in appendix 1). Although this term identification was the best we could find, the resulting term set still included terms like 'April', 'question', 'argument', 'connection', and 'long way'. Terms that clearly specify quantities or periods (e.g., 'none', 'April', 'day') were removed from the data set so as not to impair subsequent mapping and clustering.

Crosstabulation of the manual main groups with the automatic clustering showed that there was only one case of a high concentration of a main group in a single cluster: the sixth main group concerned with specific groups (Table 3). In all other cases the concentration of main groups in clusters was much lower or even negligible.

If, as in the present case, the association between manual and automatic clusters is low, the automatic clustering cannot be used to analyze the content of the body of text in question. But if that body is too large to apply full manual classification, a sample will have to be drawn. Of course, this means that the results will have a certain variance due to sampling errors. In that case, automatic clustering may be a useful tool to reduce the sampling variance. Provided there is *some* association between automatic clusters and manual groups, the automatic clustering can be used as a sampling framework with different sampling fractions in each cluster, e.g., equal absolute sample sizes per cluster. This approach of a stratified sample reduces the sampling variance compared to that when a sample is drawn from the entire population. If there is no association, the expected results of the stratified sample are the same as those from a non-stratified sample, but even a small association will already lead to a reduced sampling variance. After automatic clustering, the strength of the association can be tested by evaluating whether the manual groups are overrepresented in the automatic clusters. Therefore, employing automatic clustering as a sampling framework for manual classification is a useful approach for classifying a large body of documents.

Table 3. Crosstabulation table clustering on the basis of automatic term identification and manual classification

% of automatic clusters	*Manual clustering*						
Automatic clustering	Career conditions	Attractiveness of science as a career	Merit-based career policies	Research funding	Specific groups	Mobility	Non-relevant
1	7	9	7	14	9	24	30
2	24	2	15	2	1	2	54
3	8	3	3	14	3	0	69
4	10	26	13	5	13	10	23
5	0	0	0	0	82	5	14

2.4. Conclusion

We identified the main topics on scientific careers in *Nature* and *Science* editorials as being career *conditions* while in academia, the *attractiveness* of science as a career to potential entrants, *merit*-based career policies, the effect of research *funding* on scientists' careers, *specific groups* underrepresented in science, and the *mobility* of scientists. The opinions expressed in the editorials were fairly unanimous in the identification of problems, e.g., a lack of career perspectives for young researchers, underrepresentation of specific groups in science, only output in the form of research articles being rewarded career-wise, and a lack of mobility of scientists. The proposed solutions to these problems, however, did differ. Some were quite straight-forward (e.g., increased allocation of funding to young researchers, to specific fields etc.) or non-controversial (e.g., more attention for female applicants, career mentoring for postdocs, and scientists becoming more involved in outreach to the general public). But some editorials mentioned more controversial plans. Several editorials call for fewer PhD students to be trained, and one even argued that the example of the Beijing Genomics Institute, where the PhD has been abolished, is one to watch. One solution most editorials do agree on is that more funding for research and academic positions is needed.

In this study we have shown what the main topics in academic career policy are according to opinion leaders in science. In further work, it might be interesting to compare the results of this study to what scientists themselves deem important influences on their own academic careers, according to such surveys as are available. Similarly, an interesting line of further research might be to compare the issues addressed in the scientific literature on human resource management and careers in science with the issues identified by the editorial writers.

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PART II

Origins and development of academic career system in Germany and the United States

CHAPTER 3

The coming of age of the academic career: Differentiation and professionalization of German academic positions from the 19th century to the present

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Abstract

In modern academic career systems there are a large number of entry positions, much smaller numbers of intermediate positions, and still fewer full professorships. We examine how this system has developed in Germany, the country where the modern academic system was introduced, tracing the historical development of academic positions since the early 19th century. We show both a differentiation and professionalization. At first, professorships and private lecturer positions were the only formal positions, but later, lower formal academic positions emerged. Over the whole period, the share of higher academic positions steadily decreased. This differentiation process was closely connected to professionalization: remuneration through salaries was extended from professors to almost everyone working in the German academic system. We propose that the process of differentiation and professionalization was induced by the expansion and democratization of higher education. Finally, our study shows that the opportunities for PhDs to obtain salaried (post-)doctoral positions have increased since the 1950s. On the other hand, opportunities for PhDs to become a professor or obtain another tenured job have decreased since the 1980s due to a slowdown of higher education expansion.

3.1. Introduction: many are called but few are chosen[1]

When university graduates seek to pursue a career in science[2], they are faced with the pyramidal structure of academic positions: a large number of PhD candidates at the base and only a few professorates at the top. In most countries, graduates start their careers in "apprenticeships", first as PhD candidates and later as postdoctoral researchers, during which they are more or less considered to be "qualifying" as scientists (and in many systems seen as students during the PhD period; Singer, 2000; Taylor, 2011). During this period they are typically on scholarships or temporary employment contracts. However, even when considered as students, they do account for a large share of scientific output (Larivière, 2012; Whitley, 1984). After this probationary period, postdoctoral researchers may obtain a permanent position if successful and if a post is available (Dooris & Guidos, 2006). This means university graduates aspiring to an academic career can be employed on temporary contracts for more than ten years: first, two to five or more years as a PhD candidate, and then for up to five years or more as a postdoctoral researcher (Nerad & Cerny, 1999).

Researchers and policymakers identify problems regarding current academic careers with a high level of consensus, notably the small number of PhD candidates eventually becoming tenured staff at academic institutions and the long probationary periods (Konsortium Bundesbericht Wissenschaftlicher Nachwuchs, 2013; Waaijer, 2013). To put it another way: "many are called but few are chosen".[2] A commonly stated sentiment is that it has become more difficult to obtain professorships because their number has decreased compared to the number of PhD positions, i.e., the academic career pyramid has become narrower at the top and broader at the base.

However, these statements refer to recent decades. To fully understand why the academic career system is as it is, we need to look back further and trace how academic careers have changed with regard to numbers of different positions and their characteristics, e.g., their associated employment conditions. This enables us to determine whether the pyramidal structure has indeed become flatter, making it more difficult to obtain a professorate.

First, we consider what an academic career is, looking at the literature on jobs, occupations, professions and careers, and introduce a stylized scheme of the academic career. Second, we provide more background information regarding Germany, the country we investigate in this paper, and describe its current academic career system. Third, we describe the differentiation of

[1] Matthew 22:14 (King James Bible).
[2] In an Anglo-Saxon context, the word "science" does not refer to disciplines such as mathematics, engineering and the humanities. Following the German tradition, we will use "science" like the more general *Wissenschaft*, which does include these fields.

academic positions in Germany from the beginning of the 19th century and the developments that led to this differentiation. Fourth, we describe the professionalization of the academic career in Germany from just before the 19th century and specifically focus on the recent increase in temporary positions. We show that the differentiation and professionalization are likely due to expansion (and more specifically democratization) of higher education. Finally, we investigate the academic career opportunities for PhD graduates by looking at the number of academic positions available to them at German universities and show that the opportunities to become a professor increased from 1953 until 1965, but have decreased ever since. We show that opportunities to obtain higher, permanent, academic positions are correlated with higher education expansion: they increase when growth of higher education is large, but decrease when growth slows down.

3.2. Concepts: what is an academic career?

3.2.1. Literature: jobs, occupation, professions, and careers

In the International Standard Classification of Occupations (ISCO-88) a job is defined as "a set of tasks and duties performed, or meant to be performed, by one person, including for an employer or in self employment", and an occupation as "a set of jobs whose main tasks and duties are characterized by a high degree of similarity" (International Labour Organization, 2012). ISCO-88 classifies occupations according to skill level and specialization, but not according to job titles. For example, because the skill specialization (e.g., the field of knowledge required) of a full professor in chemistry is different from the skill specialization of a full professor in anthropology, the two are assigned to different occupational groups. This means we cannot describe the development of an academic position as the development of an *occupation* (as defined by ISCO-88), because even when academic positions carry the same job title, they may belong to different occupations.

Another classification method is the grouping of jobs into *professions*. Defining professions may be done according to various approaches (Schmeiser, 2006): a trait catalogue approach (e.g., Barber, 1963; Goode, 1961), a functionalist approach (e.g., Parsons, 1959), a power approach (e.g., Abbott, 1988; Johnson, 1972; Larson, 1977), an interactionist approach (e.g., Hughes, 1963), or a systems theory approach (e.g., Stichweh, 1987). However, no consensus in the professions literature exists as to the method of delineating the academic profession, and even as to whether academic work actually constitutes a profession (Gläser, 2012; Stichweh, 1987). Therefore, in this study we will not examine the development of academic jobs as the development of a *profession* (or multiple professions), but instead we will treat academic jobs as formal or informal *positions* and will classify them according to their job titles.

Job titles send a signal about the career stage an individual is in. A career may be defined as "a process of development of the employee along a path of experience and jobs in one or more organizations" (Baruch & Rosenstein, 1992, p. 478). The traditional view of careers is that of vertical movement through a rigid, well-defined system within one organization, but over the past decades, as careers have become more fluid, career models that are more dynamic and multidirectional have been proposed, both with regard to the position on the career ladder and between different organizations (Baruch, 2004; Peiperl & Baruch, 1997). In contrast to careers in many sectors, careers in academia are usually still quite linear with regard to positions – one typically enters at a young age, works as an "apprentice" and tries to move up the career ladder, i.e., obtain a position considered to be higher. Most researchers who do not succeed in moving up leave academia to work in another sector. Horizontal, inter-organizational mobility is quite high; especially when transitioning from the PhD to the postdoctoral phase, researchers are expected to change institutions and preferably even work abroad (Ackers, 2008; Enders & Kaulisch, 2006).

3.2.2. Structure of academic careers

In this paper we consider the structure of careers in academic research, that is, research in public institutes. Most academic research takes place in (research) universities, but it may also occur in institutes of scientific societies, e.g., the German *Max-Planck-Gesellschaft* and *Fraunhofer-Gesellschaft* (Kreckel, Burkhardt, Lenhardt, Pasternack, & Stock, 2008, pp. 65-72). However, since most career systems within such institutes are based on those of universities, we will focus here on university career systems. As a point of departure, the archetype of the modern academic career, particularly in the U.S., is shown in Figure 1. It is an hierarchical picture of five university positions with associated characteristics. This scheme is not a realistic depiction of the actual occurrence of academic positions, but is the stereotypical image of academic careers that many, even experts on academic careers, have in mind (Academic Careers Observatory, 2010). As such, it does not model positions of all leading scientific countries or periods, omits some very important characteristics, such as when tenure is granted, when one is allowed to supervise students, when one is allowed to pursue one's own research line, etcetera. The complicating aspects of the archetypical scheme are dealt with in the scheme in Figure 2. The latter makes explicit four important aspects of the academic career: how scientists perform research, the extent to which they have to attract funding, the control they have over their scientific activities and over resources (similar to Whitley's notion of control, cf. Whitley, 1984, pp. 227-234, and his notion of "protected space", cf. Whitley, 2012), and their terms of employment. These are all broken down into multiple characteristics. In addition, we sketch how we expect these characteristics to progress during a typical academic career. Progression in these dimensions is not necessarily uniform but can differ between career systems.

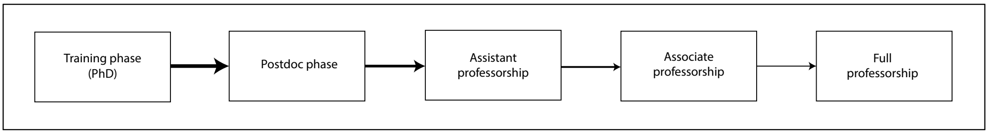

Figure 1. Archetypical academic career in the United States. The thickness of the arrows stands for the percentage of researchers moving from one position to another

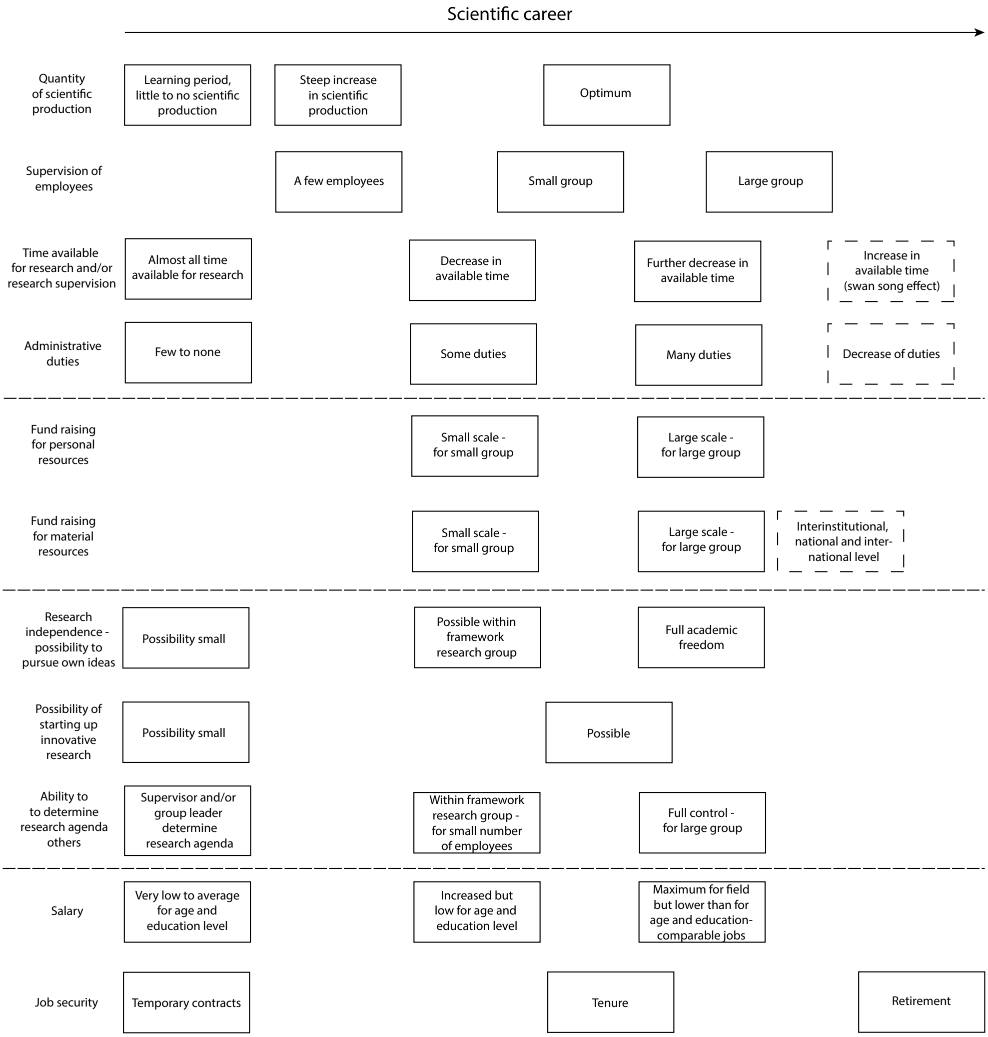

Figure 2. Structure of the academic career with its various characteristics. Horizontally the progress in the academic career is depicted; the further to the right, the higher the status of the researcher. Dashed boxes are developments that occur in some researchers' careers, but not in others'

In principle, each of the characteristics is needed to classify an academic position: salary, tenure, degree of independence, degree of supervision received or given, etcetera. Therefore, academic career systems of different countries, institutes, or scientific fields can only be compared using a multidimensional approach. In practice, however, it is impossible to collect quantitative information for long periods on each of the characteristics concerned. Instead, the scheme must be borne in mind when collecting and analyzing the data that are actually available. These data, supplemented where necessary by qualitative historical information, then serve as proxies for the characteristics underlying academic careers in Figure 2. With this approach, it turns out that a fairly good picture emerges of the German career structure from the 19th century until the present.

3.3. The German career system

3.3.1. Why Germany?

Germany is one of the leading countries in science and technology (S&T), spending 2.82% of its gross domestic product on research and development (R&D) in 2009 (OECD, 2009), having the fourth largest number of scientific publications based on the total number of citable publications in the Web of Science database in 2011 (own calculations), and having 39 universities in the top 500 research universities as measured by the Leiden 2011/2012 ranking (Centre for Science and Technology Studies, 2012). The German career system is even more interesting to study because of its historical development and the influence it has had on academic career systems across the globe. The concept of the research university originates in Prussia, from linguist, philosopher and government official Wilhelm von Humboldt. Before the 19th century, teaching students was the primary focus of universities. Humboldt introduced a model of higher education with unity of research and teaching at its core. Humboldt's idea was that students should not merely study existing knowledge, but should perform scientific work themselves, under the supervision of academic staff. Whereas the universities' focus had been to disseminate existing scientific knowledge, their focus was now on staff and students working to increase scientific knowledge (Gellert, 1993, pp. 7-9). The Humboldtian university model would be adopted by many countries and is the model on which current research universities are based.

The focus on science at German universities has likely contributed to Germany becoming the leading country in chemistry, physics and medicine from the 19th century until the end of the Weimar Republic in 1933. An example of the German dominance in science is that between 1901 and 1932 Germany was leading in the number of Nobel prizes for the sciences – a total of 32. Like the United States from the mid-20th century, Germany was the country to move to in order to work at the most prestigious institutes (Taylor, Hoyler, & Evans, 2008). It seems likely that its proven success and influence on foreign scientists made the German academic career system a standard for other countries.

3.3.2. The present system

A minor difficulty in studying the German system in an international context is terminological, as no standard translations of German job titles into English exist. In Table 1 we give an overview of the English terms we use for German positions as well as descriptions of them. Roughly four different types can be distinguished in the German academic career system: professors, lecturers, university teachers, and research affiliates and assistants. Professorships (including ordinary, extraordinary, and junior professorships) are characterized by their independent research and teaching. Lecturers (positions just below the professorship) in practice also fulfil their research and teaching tasks independently, but do not hold the professorial title.[3] University teachers have a focus on teaching and are often employed part-time. Finally, research affiliates and assistants are researchers who do not set their own research agendas, but rather assist "their" professors in the realization of the professors' research lines (Kreckel et al., 2008, p. 51).

Professorships are the highest academic positions; within this group full professorships are considered to be highest, followed by extraordinary professorships and junior professorships. Professors have much influence over the research agenda of their groups, implying that the current German system can be qualified as being fairly hierarchical. The largest group of academics is lowest in rank: research affiliates and assistants. The difference between the two positions is that affiliates are employed full-time, whereas assistants are typically employed part-time and expected to work on their PhDs for the remainder of the time. Together, the affiliates and assistants make up the early-career scientists, who are considered to be training to obtain professorships themselves (Kreckel, 2012). Academic careers typically start with a period as a PhD candidate (*Doktorand*)[4], for whom a variety of positions and remunerations exist. In the natural sciences, PhD candidates usually have a position as a research or teaching assistant, or research affiliate. In the humanities and social sciences on the other hand, the percentage of PhD candidates on a scholarship or even without any financial allowance is much higher (Fräßdorf, Kaulisch, & Hornbostel, 2012).

[3] However, strictly speaking, only researchers in the professors group perform research and teaching independently according to German higher education law (*Hochschulrahmengesetz* §43).
[4] The German translation for a female PhD candidate is *Doktorandin*. For the sake of brevity, we will use masculine forms of German terms throughout the text.

Table 1 Main current academic positions in Germany

Position	German term	Description
Professors		
Full professors	*W3 Professoren*; until 2005 *C4 professoren*	Academic staff occupying a professorial chair; responsible for research and teaching of a full scientific field.
Extraordinary professors	*W2 Professoren*; until 2005 *C3 professoren*	Academic staff independently performing research and teaching in (parts of) a scientific field.
Junior professors	*Juniorprofessoren* (W1)	Starting group leaders setting up independent lines of research.
Lecturers		
University lecturers	*Hochschuldozenten*	Academic staff, non-professorial.
University teachers		
Adjunct professors	*Lehrbeauftragte*	Freelance teacher of specific subjects.
Private lecturers and senior private lecturers	*Privatdozenten und außerplanmäßige Professoren*	Private lecturer: independent *Habilitation*-holding teacher; senior private lecturer title is given to private lecturers who have been private lecturer for 2-6 years (depending on state). Used to be the main position below professorships, but has been replaced by junior and extraordinary professorships.
Research assistants and affiliates		
Research affiliates	*Wissenschaftliche Mitarbeiter*	Junior researchers (postdocs and PhD candidates) performing research and teaching under the supervision of a professor.
Research assistants	*Wissenschaftliche Hilfskräfte*	Students assisting in research projects, often to fund own PhD research. Note: bachelor and master students providing research assistance are grouped into this category as well.

Sources: Busch, 1963; Bock, 1972; Enders, 1996; Kreckel et al., 2008; Statistisches Bundesamt, 2011.

After the PhD, researchers can obtain positions as (postdoctoral) research affiliates (the designation for doctoral and postdoctoral research affiliates is the same: *wissenschaftliche Mitarbeiter*).[5] Postdoctoral research affiliate positions are often used to work on a *Habilitation*, a "second dissertation". Researchers who have obtained this are referred to as private lecturers (*Privatdozenten*). Historically, the *Habilitation* was required to obtain the *venia legendi*, the formal right to teach at universities, which was needed until the end of the 20th century to become a full professor. In the present century an attempt has been made to reduce the role of the *Habilitation* (bringing the system in line with other countries) by introducing junior professorships (Böhmer & von Ins, 2009). With a junior professorship, scientists with a PhD can set up their own research group and research line without having obtained the *Habilitation*. In addition to professorships, so-called "habilitated scientists" may be employed as lecturers or university teachers.The employment conditions of the different positions vary; professors are typically employed on permanent contracts (with the exception of junior professors), whereas almost all research assistants and affiliates are employed on temporary contracts (Kreckel et al., 2008, pp. 45, 51). Lecturers and university teachers may be employed on either type of contract.

3.4. Differentiation of academic positions

From the mid-19th century quantitative data on academic positions are available for Germany. However, the quantitative studies employ different methodologies, especially in how they define groups of scientists. Various reasons for these differences exist: the focus of the study (e.g., focus on professors or a broader scope including other positions), the existence of positions (thus, junior professorships are a recent phenomenon), and methodological choices (e.g., are ordinary and extraordinary professors lumped together or broken down into two separate groups?). We focus on "the big picture" and sketch developments in academic career systems with such data as are available. We combine quantitative data on academic positions from various sources with qualitative scientific literature on the history of academic careers.

3.4.1. Differentiation before WWII

At the top of the 19th-century hierarchy of official academic positions were the professors: the ordinary professor (*ordentlicher öffentlicher Professor* or *Ordinarius*) and extraordinary professor (*außerordentlicher Professor* or *Extraordinarius*). The difference between the two is that the ordinary professor held a professorial chair in a broad subject, whereas an

[5] According to the German law on academic employment (*Wissenschaftszeitvertragsgesetz,* 2007), a researcher can be employed on a temporary contract (as research affiliate or assistant) for up to six years before and also up to six years after the PhD (nine for medicine). However, positions paid by third-party funding are exempt from these regulations.

extraordinary professor did not hold a chair and typically worked on a narrower subject (Eulenburg, 1908, pp. 55-60).

A third academic position in 19th-century universities was that of private lecturer (*Privatdozent*). Private lecturers were non-professorial academics giving lectures and performing research independently (Busch, 1963). A private lecturer could be promoted to extraordinary professor or directly to ordinary professor. An extraordinary professor could fill that position for his entire career, but could also later be promoted to ordinary professor. As these customs show, ordinary professorships were considered to be higher positions than extraordinary professorships (Eulenburg, 1908, p. 51; von Ferber, 1956,pp. 102-111). Some extraordinary professors received remuneration from the university, whereas others only received a professorial title by appointment as extraordinary professor (Eulenburg, 1908, pp. 3-4; von Ferber, 1956, p. 46). From the 1920s, an explicit distinction was made between paid (*planmäßige*) and non-paid, "honorary" (*außerplanmäßige*) extraordinary professorships (von Ferber, 1956, pp. 22, 82), which is reflected in university employee statistics.

Another category of employees was research assistants (*wissenschaftliche Assistenten*). We now associate these assistantships with "apprenticeship" positions for scientists at the beginning of their careers. However, originally research assistants were literally employed as assistants to professors. As described above, in the Humboldtian model, education by experimental work was considered vital for students. An assistant's job consisted of aiding experimental demonstrations by professors during lectures and of facilitating and performing experimental work for their professors. In addition, supporting personnel such as librarians and museum curators were given assistant positions. Over time, a so-called "assistant career" developed. This tiered career ladder consisted of three positions called 1st, 2nd and 3rd research assistant, which could be obtained based on age, years of service, and merit (Bock, 1972, pp. 120-121). Assistantships could become holding posts ("*Bewährungsaufstiege*") for researchers who had not been able to obtain a higher position despite excellent work, and even sometimes unofficially functioned as department heads (Bock, 1972, p. 127). This shows that the academic career structure at that time did not necessarily reflect the seniority and responsibilities of German academics. Immediately after WWI, a discussion regarding the role of the assistant position arose. Following this discussion, a differentiation was made between more permanent positions for scientifically established specialists and positions for those still qualifying as a scientist (Bock, 1972, pp. 187, 221-223). This meant the formal introduction of positions for scientific "apprentices" and a more formalized career system, with the positions assistant – private lecturer – professor comprising its stages (Busch, 1963).

To the best of our knowledge, the first study on numbers of different academic positions was performed by Christian von Ferber, who investigated the German academic career system as it developed from 1864 until 1953 (von Ferber, 1956). He counted the numbers of different types of professors, (private) lecturers, and university teachers at eleven time-points. Unfortunately, his data do not include numbers of persons working to obtain a PhD or a *Habilitation*, probably because such individuals would still be considered to be "qualifying" to become a scientist, i.e., obtain the *venia legendi*, for a major part of this period. Nevertheless, his study reveals some very interesting developments in the shares of academic positions.

Most notably he shows that the proportion of ordinary professors had steadily decreased from half of all academic employees in 1864 to approximately 25% by 1953 (Fig. 3). From 1864 until 1910 there was an increase in the share of private lecturers, but after this period it decreased again, falling below the 1864 proportion. The line showing the share of extraordinary professors is uneven as well; it suggests the share of extraordinary professors remained stable until 1920, but had increased dramatically by 1931. A possible explanation could be that honorary, non-paid extraordinary professorships, which used to be grouped with paid extraordinary professorships, were explicitly measured for the first time around 1930; after World War II the proportion had decreased again. In the whole period of von Ferber's study, the position with the largest increase in share was that of university teachers. This group, however, is a fairly heterogeneous group consisting of university teachers paid on a contractual basis, part-time professors and research candidates[6], so it is difficult to say definitively which subgroup or subgroups contributed to the increase.

The main trend in these figures (already noted by Ben-David and Zloczower [1961]) is that the share of ordinary professorships declined, whereas other positions below the professorship (private lecturers, extraordinary professors and a heterogeneous group of [part-time] university teachers and scientists) grew. Our analysis shows that different positions took turns "filling the gap" left by the relative decrease in ordinary professorships.

The conclusion that positions below the professorship became more prevalent is further supported by von Ferber's analysis of the relative numbers of private lecturer positions and non-paid extraordinary professorships in comparison to the numbers of the ordinary and paid extraordinary professorships. The analysis shows that the relative number of private lecturers and non-paid extraordinary professors increased dramatically over time, especially in medicine and the natural sciences (Fig. 4).

[6] Von Ferber referred to them as "*Kandidaten der wissenschaftlichen Forschung*", which most likely indicates researchers working on a *Habilitation*.

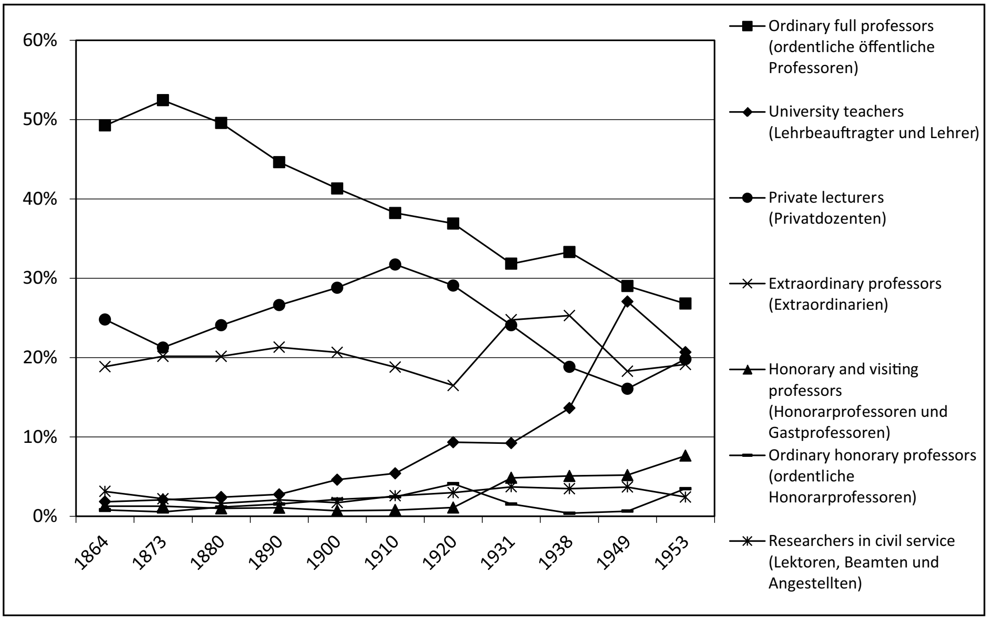

Figure 3. Distribution of academic positions at German universities by academic rank, 1864-1953. For 1953 West Germany only. Source: von Ferber, 1956, pp. 195, 210

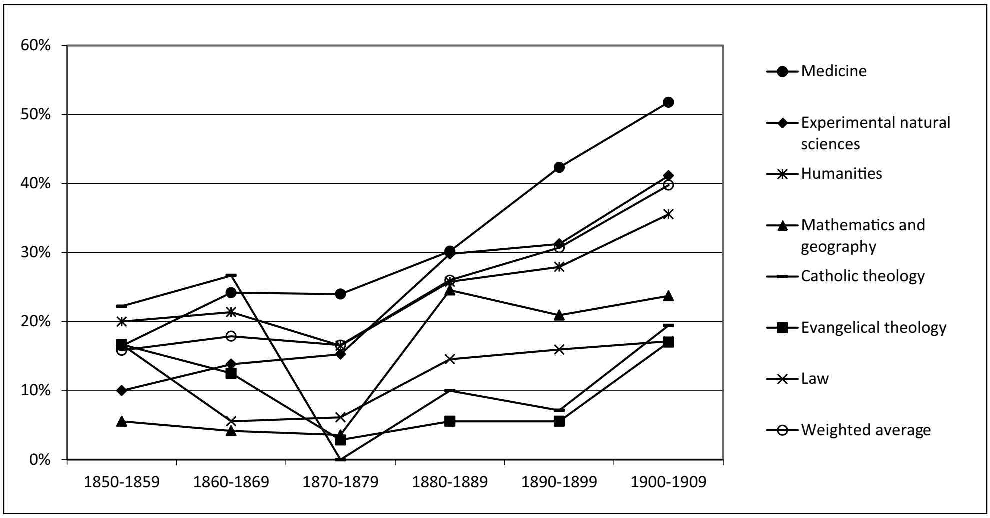

Figure 4. Private lecturers plus non-permanent extraordinary professors as a percentage of all higher academic positions per subject area. Source: von Ferber, 1956, p. 81

3.4.2. Differentiation after WWII

To investigate the distribution of academic positions from around 1950 until now, we turn to publications on this subject by the German Federal Statistical Office (*Statistisches Bundesamt*) published from 1952 (Statistisches Bundesamt, 1953; 1966; 1969; 1976; 1982; 1992b; 2001;

2004b; 2011). They not only contain the numbers of professors, lecturers, and university teachers, but also of other university employees. This means that data on research affiliates and assistants can now be incorporated into our analysis. A limitation of these publications is that their classification of academics has changed over the years due to the fact that designations and job descriptions have changed; this makes it difficult to track the development of specific positions. Therefore, we show differences in the academic career system by showing the development of the four groups of positions we discussed above: professorships (ordinary, extraordinary, and junior professorships), lecturer positions, university teacher positions, and research affiliate and assistant positions. An overview of all current academic positions as distinguished by the German Federal Statistical Office and a description of these positions is given in Table S1 in appendix 2).

These data show that the relative number of professorships (ordinary, extraordinary, and junior) declined even further from close to 30% in 1953 to approximately 10% in 2010. This decline is due to the appointment of a large number of research affiliates and assistants; their percentage rose from about 40% to almost 70% (Fig. 5). In addition, the share of lecturers declined. The share of university teachers remained stable over this period (except for a dip in the 1960s). In conclusion, the current German academic career system of research positions is characterized by a small top of professorships, few intermediate positions, and a broad base of junior research positions.

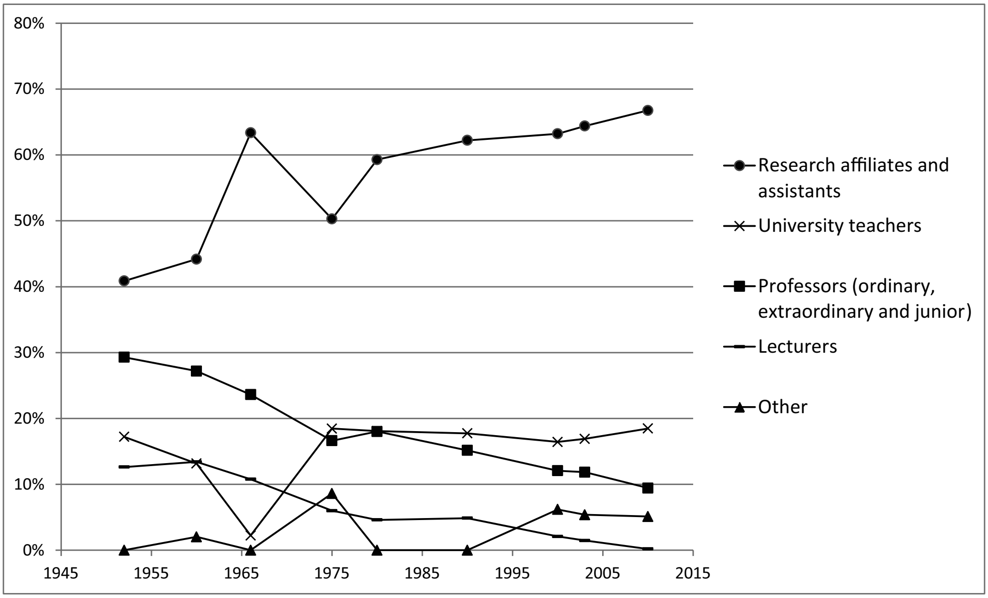

Figure 5. Distribution of academic positions at German universities by academic rank, 1952-2010. For 1953-1990 West Germany only. Source: Statistisches Bundesamt (Personal an Hochschulen, 1953-2011)

3.4.3. Conclusions and possible causes

It is quite clear from the above description that the stereotypical academic career of Figure 1 cannot be used to describe the development of the German career system. Instead, the more elaborate concepts of Figure 2 are needed to understand the available data. These data show that from the early 19th century on, a differentiation of formal academic positions took place. Whereas at the beginning of the 19th century the only official positions had been professorships and private lecturer positions, later new positions such as research affiliate arose. Furthermore, there were changes in the relative numbers of positions – the proportion of lower academic positions grew, whereas that of the highest academic positions (professorships) steadily declined. This does not necessarily mean that the ratio of "trainee" scientists to professorships increased, however. Before the full formalization of PhD and *Habilitation* work in research affiliate/assistant positions, scientists pursuing their PhD and *Habilitation* were already working in the science system, only they were not included in university employee statistics.

The main question arising from the continued differentiation towards (formal) academic positions for academics working on a *Habilitation* and PhD is what could have caused this development? The differentiation of academic positions was part of the exponential growth since the 16th or 17th century in the number of people we would now call scientists. This growth led to large absolute increases in the number of scientists in the 19th century, which were especially apparent in Germany (Gascoigne, 1992, pp. 556-557).[7] Later, further expansion, and importantly, democratization of higher education occurred: the access to higher education expanded to students from all social backgrounds.[8] Even before the beginning of the 20th century, children from middle-class families were increasingly enrolling at universities (Windolf, 1997, pp. 55-56). However, it was not until after WWII, when the number of students at universities grew rapidly, that more children from lower-class families started going to university (Enders, 1996, p. 64; Windolf, 1997, p. 57). In the 1950s, the educational burden on assistants due to the expansion of higher education had become so great that they did not have enough research time to pursue a *Habilitation*. As the growing numbers of students also meant an increase in universities' resources, more assistants could be hired. Whereas it had been common for professors to have one assistant at their disposal, in the 1960s they were able to hire two or even three (Bock, 1972, pp. 194-195). Thus, the expansion of higher education had led to an increased demand for academics.

Literature on organizational structure shows a larger size of organizations may be correlated with an increased vertical span of control (Pugh, Hickson, Hinings, & Turner, 1968; Hinings

[7] An exponential growth has also been observed in the number of scientific papers (De Solla Price, 1963; van Raan, 2000).
[8] Defined as "external democratization", in contrast to "internal democratization", which is employees' and students' involvement in university governance (Hermans, 2002).

& Lee, 1971). Our data suggest a similar mechanism was at play at German universities. An important difference, however, is that there was no increase in the vertical span of control *per se* (no additional types of positions between professorships and affiliate positions were introduced in the 1960s and 1970s). Instead, the number of people in the pre-existing types of lower positions was increased relative to the number of professorial positions (also noted by Enders [1996, pp. 59-79]). This increase in the number of researchers in pre-existing types of lower positions rather than an increase in the vertical span of control might be due to the traditional master-apprentice relationship in science (Huisman, de Weert, & Bartelse, 2002).

3.5. Professionalization of academic positions

In addition to the differentiation of academic positions, a professionalization of science took place, as research became a fully paid job over the course of the 19th and 20th century. Furthermore, the ways in which scientists were remunerated have varied throughout this period. In this section we show developments in the professionalization of academic positions using various qualitative and quantitative sources.

3.5.1. Remuneration before the 19th century

Before the 19th century, across the world scientific research was not ordinarily remunerated through paid research jobs, but mostly performed by amateurs who were paid through other occupations (Ben-David, 1972; Crosland, 1975; Hahn, 1975). This is not to say these amateurs provided sub-standard work; like Crosland in his paper on the professionalization of academic careers in France, we use the terms "professional" and "amateurish" not as an indicator of the quality of the work but in a strictly occupational sense, i.e., being paid for scientific work or not (cf. Crosland, 1975). Furthermore, before the French Revolution, science and literature were not clearly demarcated (Crosland, 1975). The first steps towards the professionalization of science were taken with the foundation of Academies of Science, which gave out allowances to their members. However, these allowances were hardly sufficient to support a family (Hahn, 1975). During the French Revolution and the subsequent Napoleonic wars, scientific knowledge was increasingly valued for practical (war-time) use, and consequently, scientific work became a fully paid job. This led to a differentiation between science on the one hand and literature on the other. But whereas scientific research in France was now more fully recognized through paid employment, it took place at other locations than the university alone (Ben-David, 1972). This was different in the German states, where, due to the introduction of the research university, research and teaching were practised jointly within the universities.

3.5.2. Professionalization from the early 19th into the 21th century

Even though all formal academic positions existing at the beginning of the 19th century constituted "paid employment" as we define it now (International Labour Organization, 1993), the mode of remuneration and security of positions varied. Of the three official academic positions, only ordinary professors were paid salaries from the universities. As mentioned above, this was not always the case for extraordinary professors: some received salaries, whereas for others the professorial title was only honorary. The third position, private lecturer, was not remunerated by the universities (Ben-David & Zloczower, 1961; Weber, 1918). Instead, private lecturers were paid on a "freelance" basis through lecture fees they had to collect directly from their students (Weber, 1918). All types of academics received lecture fees (Eulenburg, 1908), but ordinary and paid extraordinary professors were less dependent on them. Thus the private lecturer's income was variable and uncertain. The uncertain nature of the private lecturer position has even been described by Busch (1963) as "they [the private lecturers] were more or less without rights, but they were under great pressure to do good work as scientists and as teachers. The *Privatdozenten* were, in a sense, the 'proletarian reserve army' serving the 'ruling class' of full professors." (Busch, 1963). By 1875, however, industrialization had led to a greater demand for highly educated individuals in other professions and the pool from which to draw professors had shrunk. Therefore, the Prussian Minister of Education established a fund to give stipends to private lecturers (Busch, 1963). Still, according to Busch, private lecturers remained underpaid as these funds were "chronically exhausted" (Busch, 1963, p. 331).

The government fund was an important yet not the only possible source of income for private lecturers. The position of assistant, which was first used for employees who literally assisted professors, later became a salaried position for scientists striving for a professorship (Bock, 1972). As such, it was used to appoint both those pursuing a *Habilitation* and those who had already obtained it, i.e., private lecturers (Eulenburg, 1908). Thus, a scientist could be both private lecturer and assistant: the private lecturer title gave the academic right of *venia legendi* and the position of assistant provided remuneration (Busch, 1963).

As described above, the position of assistant became more formalized after WWI. In addition, assistants' salaries were set out precisely (Busch, 1963). In contrast, the legal position of private lecturers did not change and they did not have formal financial security. However, in practice, by this time they were assured of a steady income through various forms of remuneration (Busch, 1963).

Table 2 Research affiliates at German universities on permanent contracts, 1980 and 1990

	All fields	Humanities (excluding art)	Sports science	Social sciences	Mathematics and natural sciences	Medicine	Veterinary medicine	Agricultural, forestry and nutritional sciences	Engineering	Art and art history	Central office and not specified
1980											
Total number of research affiliates	36914	4515	379	3393	8655	9548	434	1136	5858	363	2633
Of which on a permanent contract (%)	47.9	64.2	86.8	36.0	46.1	43.8	31.1	55.6	39.8	81.0	64.1
1990											
Total number of research affiliates	66409	6428	395	5408	17900	18864	564	1746	9775	608	4721
Of which on a permanent contract (%)	26.5	37.0	50.1	21.5	21.6	26.3	21.5	17.4	25.6	52.6	38.0

Sources: Statistisches Bundesamt, 1982, p. 22; 1992, p. 20. Research affiliates on permanent contracts: *akademische/wissenschaftliche Oberräte auf Dauer, akad./wiss. Räte auf Dauer*, and *wissenschaftliche und künstlerische Mitarbeiter auf Dauer*. Research affiliates on temporary contracts: same job titles, but *auf Zeit* instead of *auf Dauer*.

In the 1960s, research affiliate positions were not only used to employ private lecturers or scientists working on a *Habilitation*, like before WWI (von Ferber, 1956), but also to employ scientists working on a PhD (Bock, 1972). Thus, virtually all academic positions became formal, salaried positions. The fact that academic degrees are conferred for work performed in these paid jobs shows the dual role of the research affiliate or assistant (cf. Enders, 1996): on the one hand, "qualifying" to become a scientist, while on the other hand being paid as an actual scientist, and accounting for a large share of scientific output (Larivière, 2012; Whitley, 1984).

3.5.3. Temporary contracts

As described above, the first 70 years of the 20th century saw PhD candidates and postdoctoral researchers increasingly becoming paid employees. At the end of that period, many of them had an employment contract. The share of permanent contracts for research affiliates differed per scientific discipline, but in 1980 on average almost one-half had a permanent contract (Table 2). After 1980, there was a change in the other direction as the share of permanent contracts declined. Differences in the share of permanent contracts persisted across disciplines, but this share did decrease among all. By 1990, on average three-quarters of the contracts were temporary. The halving of the share of permanent contracts during the 1980s was only the beginning. This trend has continued and these days, permanent contracts for research affiliates are a rarity (Kreckel et al., 2008).

3.5.4. Conclusions and possible causes

The main trend in the remuneration of German academics is a sustained professionalization: whereas at the beginning of the 19th century professorships were the only salaried positions at universities, later on positions below the professoriate became paid, down to the position of PhD candidate. Employment security varied as well, as private lecturers were first remunerated on a "freelance" basis, and later through stipends, or, alternatively, through employment as research assistants. On the other hand, whereas in the years following WWII more research affiliates were getting permanent contracts, this trend has been reversed and affiliates are increasingly employed through temporary contracts. This reverse trend took place against a background of liberalization of the entire public sector, of which the main proponents were the Reagan and Thatcher administrations in the United States and the United Kingdom, but which was also followed to some extent in Germany by the Kohl administration (Engartner, 2007). This liberalization led to an increase in temporary contracts in the whole public sector (Hassel, 2011). Furthermore, there has been an increase in the importance of third-party funding (*Drittmittel*) in German science. For example, the percentage of research affiliates paid from third-party funding increased from 16 per cent in 1975 to 21 in 1980 and 32 in 1990 (Table S2 in appendix 2). By 2011, one-third of the total university budget came from third-party funding (Statistisches Bundesamt, 2014). It is likely that the increase in importance of third-party funding has contributed to the increase in temporary contracts. On the other hand, of all *wissenschaftliche Mitarbeiter* with a permanent contract in 1980, one-third was paid from third-party funding, so at least during this period third-party funding and permanent job contracts were not mutually exclusive (Statistisches Bundesamt, 1982).

The democratization of higher education not only led to changes on the *demand* side of the academic labour market, but also to changes on the *supply* side, as more children from middle- and lower-class families were going to university (Windolf, 1997). Following the democratization of undergraduate education, an increase in the share of PhD candidates from the middle and lower classes was to be expected. These individuals could not easily afford to work on their doctoral and *Habilitation* dissertations unpaid, so a need developed to compensate the lower academic ranks financially (see for example Bock, 1972, pp. 188-89 for an example of this reasoning). The early 20th century saw an increase in the share of habilitated academics whose fathers had not obtained a university diploma – from 9 per cent in the 1890-1919 period to 26 after 1945 (von Ferber, 1956). This process of PhD democratization continued and by 1955 already 39 per cent of all PhD graduates were from lower- and lower middle-class families (Hartmann, 2002). This share further increased to 46 in 1985. Conversely, the share of PhD graduates from the absolute upper classes (*Großbürgertum*, making up only one-half of a per cent of the general population [Hartmann, 2002]) had decreased from 15 in 1955 to 8 per cent by 1985. These data show that the democratization of higher education has contributed to both the differentiation and professionalization of academic positions.

3.6. Being called and being chosen: academic career opportunities for PhD graduates

A focal issue in academic career policy is the imbalance between the number of people entering the scientific workforce (i.e., PhD candidates) and the number of available faculty positions (Waaijer, 2013). A common sentiment is that it is more difficult for today's new PhD candidates to obtain a permanent faculty position than it was a few decades ago, but hard facts on this issue are lacking. To determine whether it has actually become more difficult, one has to look at the supply (academic jobs) and the potential demand (PhD graduates) in the academic job market. We have calculated the ratio of the numbers of different academic positions and the number of successful PhD defences (with interpolated data for years with missing figures).[9]

[9] For the missing years, we have estimated the number of positions and successful PhD defences by interpolation. I.e., $x_t = x_l \cdot (1 + g_{s-l})^{t-l}$, where x_t is the number of positions at time t, x_l is the number of positions at the last available time-point, g_{s-l} is the average annual growth rate in the number of positions between time s (subsequent available time-point) and time l (last available time-point), and $t - l$ is the number of years between time t and time l.

We have only included positions that imply (full-time) university employment. For example, honorary and visiting professors, freelance teachers (*Lehrbeauftragte*) and research assistants (*wissenschaftliche Hilfskräfte*) were excluded as these are not typically positions upon which an academic career is built. The ratio between positions and finished PhDs provides an estimate of the career opportunities available to PhD graduates: an "opportunity ratio". In this analysis one must take into account that it takes time to obtain some of the positions. Therefore, we have compared the number of successful PhD defences from one year with the number of positions a certain number of years later. First, we will show the results of this analysis for (ordinary, extraordinary and junior) professorships. Within the investigated period, the average age at PhD graduation ranged from 31.0 to 33.0 (Table S3 in appendix 2). Meanwhile, the average age of those obtaining a professorship ranged from 38.1 to 44.3 (Table S4 in appendix 2). The difference between the two is seven to eleven years. Germany, however, has a relatively large number of external PhD candidates who work on a dissertation in addition to their non-research jobs. This causes a relatively high average age at PhD graduation (Kehm, 2009). In most cases, external PhD candidates do not aspire to an academic career. PhD candidates who do have these ambitions and later become professors, start *and* finish their PhD at an earlier age on average than the total group of PhD candidates. Therefore, a period of 15 years between PhD and professorship seems reasonable. Consequently, in the calculation of the "professorship opportunity ratio" for 1953 PhD graduates, we divided the number of professorships in 1968 by the successful PhD defences in 1953. For persons who obtained their PhDs between 1953 and 1965, the opportunities for professorships had improved (Fig. 6a). However, from then on, opportunities have steadily declined, and are now almost back at the immediate post-WWII level.

For the position of lecturer the situation is quite similar. We took 10 years between PhD graduation and becoming a lecturer. It became relatively easier to obtain a lecturer position for PhD graduation from 1953 until 1965 (Fig. 6b). From then on, opportunities decreased again. This can be explained by the fact that hardly any researchers are being appointed as lecturers anymore; the position of lecturer is becoming extinct in Germany (cf. Fig. 5).

For university teacher positions, we also assumed a period of 10 years between PhD graduation and obtaining a position. Before 1975, statistics on academic employees did not distinguish between full-time and freelance university teachers (among which the largest group are the *Lehrbeauftragte*). Therefore, we chose to analyze the data for university teachers from 1975 (PhD in 1965). Their opportunity ratio has fluctuated to a small extent, but has remained relatively stable compared to that for the other types of positions (Fig. 6c).

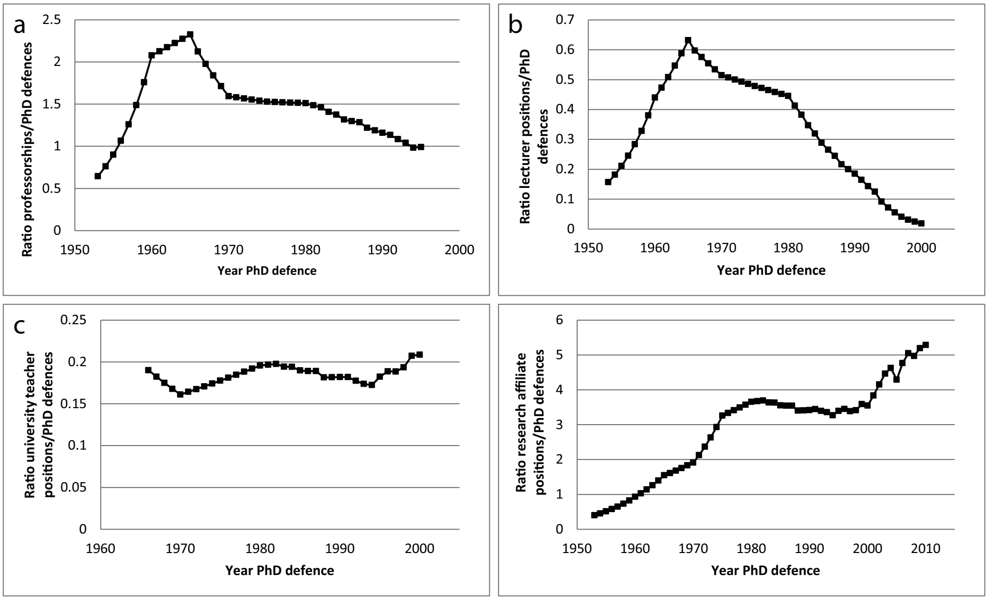

Figure 6. Opportunities per year. The ratio between the number of academic positions and number of successful PhD defences is depicted assuming a fixed period between PhD defence and eligibility for the position (data for missing years interpolated). For 1953-1992 West Germany only.
(a) Professorships (ordinary, extraordinary, and junior): 15 years between PhD and eligibility for position. (b) Lecturer positions: 10 years. (c) University teacher positions: 10 years. (d) Research affiliate positions: none.
Sources: Statistisches Bundesamt, 1953-2012

Finally, we look at the opportunities for becoming a research affiliate. Our analysis shows that the opportunity ratio for affiliates has greatly increased over the investigated period (Fig. 6d). Unfortunately, German federal statistics do not distinguish between doctoral and postdoctoral research affiliates. This makes it impossible to conclude whether the increase is due to relatively more PhD candidates obtaining positions as an affiliate, more postdoctoral researchers obtaining such positions, or a combination of both.

A cautionary note in interpreting these results which bears repeating is that in Germany a PhD not only serve as a gateway to an academic career, but also as a degree that increases a person’s standing in the non-university sector (Konsortium Bundesbericht Wissenschaftlicher Nachwuchs, 2013). An increase in the share of PhD graduates who do not aspire to a further academic career effectively increases the career opportunities for those who do. Thus, the *demand* for professorships does not have to be proportional to the number of PhDs. Still, the opportunity ratio serves as an indicator of the *supply* of career opportunities relative to all of those who have become qualified, i.e., PhD graduates.

These significant changes in the opportunities for progressing from PhD to higher academic positions are highly correlated with the large university expansion and subsequent slowdown of this expansion. Figure 7 shows the growth rate of all academic positions per year plotted against the opportunity ratios of the different positions.[11] For all positions, an increase in the ratios can be observed for the 1953-1975 period, when there was a large increase in the total number of positions. However, when growth slowed down, opportunities to obtain a professorship or lecturer position decreased (Fig. 7a-b). Conversely, opportunities for university teacher positions remained quite stable, and opportunities for research affiliate positions mainly increased (Fig. 7c-d). This suggests that when universities undergo massive expansion, like they did between 1961 and 1975, the opportunity to be appointed to an academic position increases for PhD graduates. But when this expansion slows down again, opportunities for the higher academic positions decrease.

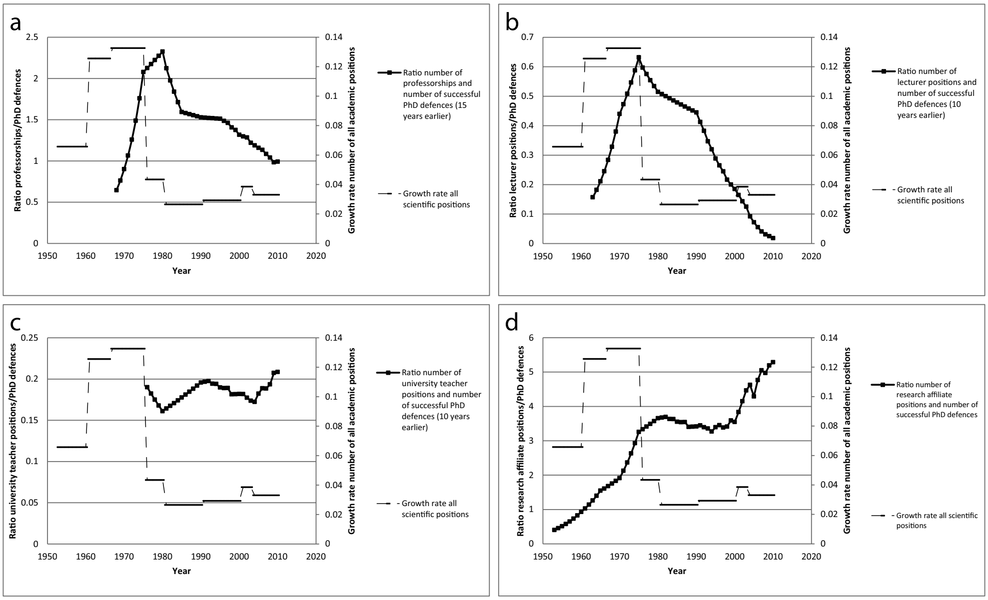

Figure 7. Relationship between career opportunities and growth of the university system. The growth rate of all scientific positions is plotted, as are the opportunity ratios (defined as in Fig. 6) for the year in which a position is obtained.[10] Periods between PhD and eligibility for a position as in Figure 6. For 1953-1992 West Germany only.
(a) Professorships (ordinary, extraordinary, and junior). (b) Lecturer positions. (c) University teacher positions. (d) Research affiliate positions.
Sources: Statistisches Bundesamt, 1953-2012

[10] In this figure, the ratios are plotted for the years of obtaining the positions, instead of the year PhD was obtained (as in Fig. 6).

Ben-David and Zlowzower (1961) already described for Germany from the 19th century until the end of WWII that in times of large expansion, many researchers are appointed on permanent contracts, but when the expansion slows down, there is almost no room for new hires. Here we show that the same holds true after WWII. Opportunities to obtain positions that usually entail a permanent contract (i.e., professorships) decrease. Conversely, opportunities to obtain positions that typically entail a temporary contract (i.e., a research affiliate position) increase, despite the slowdown of university expansion. This suggests that universities use temporary contracts as a "coping mechanism" when their growth slows down.

3.7. Discussion and conclusions

With respect to academic careers as conceptualized in Figure 2, we can conclude that in the 19th century, official academic positions in Germany were only found in what we would now call the higher echelons of the academic career ladder and that over time, through a process of differentiation, positions below the professorate became formal academic positions of their own. The primary official academic positions used to consist only of the professorate and the position of private lecturer. Within this group, the share of ordinary professorships already declined in the 19th century. During this period, aspiring scientists working towards a *Habilitation* did not occupy official positions. This began to change in the second half of the 19th century with the emergence of larger laboratories, where research assistants contributed to experimental science. By the mid-20th century, PhD candidates also often held formal positions as research affiliates. The 1960s saw a disproportionate growth in the share of these lowest positions, so many more researchers could be employed as a doctoral or postdoctoral researcher.

Terms of employment such as salary and tenure have changed in step with differentiation in a professionalization process. At first, only professors were paid; later, researchers in lower positions were remunerated as well. In the 19th century, this only applied to *Habilitation*-holding academics, but later also to those working on a PhD or *Habilitation*, by employment as a research affiliate or assistant. Our data show that the current era of "probationary periods" as a research assistant or research affiliate on temporary contracts have replaced an era ending in the 1980s when trainee scientists were quite often employed on permanent contracts. However, in an even earlier era, trainees were still considered as students when working towards a PhD or *Habilitation*. Arguably, the current situation constitutes an improvement in employment conditions for PhD candidates and postdocs *vis à vis* the 19th century, but a disimprovement *vis à vis* 1960-1980.

In this paper, we have treated the characteristics of the academic career scheme in Figure 2 independently of each other, and focused mainly on terms of employment, level of control over scientific activities and resources, and level of supervision to characterize positions. However, the different characteristics may well influence one another. Interesting questions to be addressed in future research are whether terms of employment influence the level of control over scientific activities (i.e., does an increase in temporary contracts lead to less innovative research?) (cf. Whitley, 2012), and whether the source from which funds are obtained in turn influences terms of employment (i.e., does an increase in third-party funding lead to an increase in temporary contracts?).

Our research shows that developments underlying the differentiation and professionalization of the academic career are the expansion of the university system and the democratization of higher education. The massive expansion during the 1960s and 1970s and its subsequent slowdown have influenced career opportunities in academic research. PhD graduates' opportunities to become a professor or lecturer first increased from 1953 until 1965, but have since decreased. Opportunities to become a university teacher have remained stable. On the other hand, opportunities to obtain a (temporary) position as a research affiliate have increased substantially despite the slowdown of higher education expansion.

3.8. References

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CHAPTER 4

Stability and longevity in the publication careers of U.S. doctorate recipients

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Abstract

Since the 1950s, the number of doctorate recipients has risen dramatically in the United States. In this paper, we investigate whether the longevity of doctorate recipients' publication careers has changed. This is achieved by matching 1951-2010 doctorate recipients with rare names in astrophysics, chemistry, economics, genetics and psychology in the dissertation database ProQuest to their publications in the publication database Web of Science. Our study shows that pre-PhD publication careers have changed: the median year of first publication has shifted from after the PhD to several years before PhD in most of the studied fields. In contrast, post-PhD publication career spans have not changed much in most fields. The share of doctorate recipients who have published for more than twenty years has remained stable over time; the shares of doctorate recipients publishing for shorter periods also remained almost unchanged. Thus, though there have been changes in pre-PhD publication careers, post-PhD career spans remained quite stable.

4.1. Introduction

The career system in modern day academia is typically pyramidal in structure with relatively few professors at the top and many PhD students at the bottom. The shape of this pyramid may differ by country, the United States for example having relatively more researchers in its highest academic position than Germany (Kreckel, Burkhardt, Lenhardt, Pasternack, & Stock, 2008). In most cases, supply exceeds demand: more PhD students and postdoctoral researchers indicate they would like to have an academic research career than there are positions available (Cyranoski, Gilbert, Ledford, Nayar, & Yahia, 2011; "Make the most of PhDs", 2015; Stephan, 2012, pp. 170-171). Indeed, studies have shown that opportunities to occupy tenured or tenure track faculty positions in academia have decreased, as the number of such positions has not kept track with the number of doctorates awarded (Pavlidis, Petersen, & Semendeferi, 2014; Petersen, Pavlidis, & Semendeferi, 2014; Schuster & Finkelstein, 2006, pp.193-197; Stephan, 2012, pp. 159-161; Waaijer, 2015).

The concomitant growth in doctoral students and decline in the growth rate of tenure track positions have raised concerns about the ethics of doctoral education. For example, Ioannidis, Boyack, and Klavans (2014), found that only 1% of the scientific workforce is continually publishing and admonished the educational system for utilizing doctoral students as "a cheap workforce for materializing resource-intensive incremental research agendas." They assert that this research system "may be exploiting the work of millions of young scientists for a number of years without being able to offer continuous, long-term stable investigative careers to the majority of them". This assertion, however, is relatively untested. Although the proportion of doctoral graduates obtaining tenure track jobs in academia is decreasing (National Science Board, 2014), "investigative careers" can be found in a number of positions within the scientific workforce. Systematic investigation, therefore, is necessary to ascertain the proportion of doctorate recipients who continue to contribute to the advancement of knowledge, regardless of position status and type.

Many doctoral students contribute to scholarship during their doctoral training. For example, in a study of Québec scholarship, it was noted that students were authors on a third of academic articles (Larivière, 2012). Publication during the doctoral program was correlated with degree completion and continuing productivity. There are, however, no equivalent studies of the degree to which students in the United States participate in scholarship and when, relative to the conferral of the doctoral degree, they first publish. Furthermore, we lack information on the length of the publishing careers for these individuals. Concerns about the stability of the investigative careers are often linked with the conversations around the erosion of tenure in the United States. That is, have the changes in the composition of the academic workforce replaced long investigative careers with more volatile short-term and temporary positions?

The present study provides a novel perspective by empirically measuring the investigative careers of U.S. doctoral students. Rather than analyzing the proportion of doctoral graduates entering into various career types—as previous studies have performed (Auriol, Misu, & Freeman, 2013, p. 19; Stephan, 2012, pp. 159-161)—this study focuses on the proportion of doctoral graduates who publish and the length of their publication careers. To analyze variation by both time and field, we analyze doctoral graduate from 1951-2010 across five fields (astrophysics, chemistry, economics, genetics, and psychology). We seek to address the following three research questions:

1. How has the proportion of doctoral graduates who publish academic articles changed from 1951 to now?
2. How has the year in which doctoral students publish their first academic article changed through time?
3. How has the length of the investigative career for doctoral graduates changed through time?

The strength of the scientific workforce directly translates to improved economic, health, and social well-being. For a country to be scientifically competitive, it needs to maximize its human intellectual capital-base and invest in this resource. As stated in the Science and Engineering Indicators (National Science Board, 2002, p. 5-24), "the pursuit of new knowledge, the training of the people in whom it is embodied, and its exploitation toward generating innovation, makes academia a national resource whose vitality rests in the scientists and engineers who work there". In order to better understand this national resource, it is imperative that we replace anecdote with evidence—specifically, with a more nuanced understanding of the contribution of doctoral graduates to the advancement of knowledge and the stability of publishing careers for these individuals.

4.2. Data and methods

4.2.1. Data

4.2.1.1. ProQuest database

The ProQuest Dissertations and Theses database was used as a source of data on U.S. doctorate recipients. This database, provided by ProQuest LLC, offers "comprehensive historic and ongoing coverage for North American works" (ProQuest LLC, 2015). Evidence of the comprehensiveness of the database is provided by the fact that the U.S. Library of Congress, which "strives to hold copies of all U.S. doctoral dissertations", uses the ProQuest database as an indexing service of U.S. doctoral dissertations (Library of Congress, 2008).

The data were provided in XML format in March 2012 and cover over 2.3 million dissertations completed between 1743 and 2012. Most of these are doctoral dissertations (rather than other types of theses; Ni, 2014, pp. 90-91) and a large majority have been written at U.S. institutions (Andersen & Hammarfelt, 2011). A total of 1,668,925 dissertations completed in the course of a research doctorate from a U.S. institution are indexed in our version of the ProQuest database (Ni, 2014). To determine the suitability of the ProQuest database as a source of U.S. doctorate recipients, we compared the number of research doctorates indexed in ProQuest by year to the number of research doctorates according to NSF data (National Science Foundation/ National Center for Science and Engineering Statistics, 2006, 2014a). This comparison shows that numbers are very similar, especially from the mid-1960s (Fig. S1A in appendix 3). A true measure of coverage would compare whether doctorate recipients in one source are also in the other source, and vice versa, but here such an analysis is not possible. Thus we have to limit ourselves to measuring the ratio between the number of research doctorates indexed in ProQuest and the number given by the NSF. This ratio shows that the number of research doctorates indexed by ProQuest is only 20% for the start of the 1950s, but quickly increases to over 90% for the years after 1965 (Fig. S1B). Although "coverage" of the ProQuest database may be lower in the 1950s, trends in the increase and decrease of doctorate recipients are mirrored closely.

The research field(s) in which the doctorate has been completed is also stored in ProQuest. ProQuest distinguishes 165 "disciplines" (major fields), such as anthropology, biology, physics, and sociology. These disciplines are divided into 432 "specialties" (subfields). Five disciplines/specialties were selected for our analysis: astronomy and astrophysics (specialty; in the remainder of the paper shortened to "astrophysics"), chemistry (discipline), economics (discipline), genetics (specialty), and psychology (discipline). Thus the selection includes fields from the natural, life, and social sciences. We chose fields with a considerable number of doctorate recipients from the 1950s, so as to make longitudinal analysis possible. This criterion meant that a field like molecular biology, where the number of PhD graduates was in the single digits until the late 1970s, could not be selected. The selected fields also satisfy the criterion of good coverage by the WoS (Moed, 2005). Astrophysics, economics, and genetics are all basic research fields, in which a PhD degree is mostly the gateway towards a research career (National Science Foundation/National Center for Science and Engineering Statistics, 2014b). On the other hand, industry is a major post-PhD sector of employment for chemistry and psychology doctorate recipients; in the former are employed in the chemical industry and in the latter, many doctorate recipients are involved in clinical work (National Science Foundation/National Center for Science and Engineering Statistics, 2014b).

Furthermore, all selected fields are relatively monodisciplinary and have a set of core journals. To prevent false positives we introduced the condition that at least one of the papers published by a PhD graduate should be in the field of their dissertation (see "Retrieval of papers" section). For example, someone may have received a PhD from a neurology department and thus be listed as a neurology PhD graduate, but have only published papers in molecular biology journals.

The number of doctorate recipients varies heavily by field: the largest field is psychology, followed by chemistry and economics according to ProQuest (Fig. S2). The specialties genetics and astrophysics, as specialties instead of fields according to ProQuest, were smaller. As expected (Berelson, 1960), the conferral of doctoral degrees in all fields showed large increases after the 1950s.

4.2.1.2. Web of Science database

The Web of Science (WoS), a large bibliographic database that covers a period from 1900 to the present, was used as a source of scientific articles. The WoS version we used is maintained at the Observatoire des Sciences et des Technologies (OST), Université de Québec à Montréal (UQAM), Canada, and contains the Science Citation Index Expanded (SCIE), the Social Science Citation Index (SSCI) and the Arts and Humanities Citation Index (AHCI). This database employs NSF's Science and Technology Indicators journal classification of two levels for research fields (National Science Board, 2006), which divides publications into twelve disciplines. These disciplines are further subdivided into 134 specialties. As Moed describes in his handbook on citation analysis (Moed, 2005), the WoS covered approximately 7,500 scientific journals in 2005, which were selected to cover the most important scholarly communication. However, coverage varies by discipline – as the use of journals for scholarly communication is different in various disciplines – and so does the inclusion of journals in the WoS.

In this study, the determination of publication career spans and the first year of publication is limited to the WoS. It should be kept in mind that in earlier years, fewer journals were indexed in the database (Fig. S3), which may lead to a smaller likelihood of publications being included in our analysis than in recent times. At the same time, fewer scientists were active in the earlier period (De Solla Price, 1963). Assuming the increase in the number of journals follows the increase in the number of scientists, the expansion of the WoS does not affect our results. Indeed, the growth in the number of journals in the database (Fig. S3) has been quite similar to the growth in the number of U.S. doctorate recipients (Fig. S2). In chemistry and psychology, the large growth in both the number of doctorate recipients and the number of journals in the 1990s is especially apparent in the figure. On the other hand, the growth in the number of journals in, particularly, economics and psychology from 2007 is not matched by an increase in the number of doctorate recipients – a fact that should be kept in mind especially when interpreting the share of doctorate recipients publishing one or more papers (see Results section).

4.2.2. Linking ProQuest and WoS

4.2.2.1. Linking strategy

In order to measure the year of first publication and the publication span of doctorate recipients, publications should be attributed correctly to each recipient. However, in practice, a publication may not be attributed to a person having authored that publication (false negative) or a publication may be attributed to a person who has not authored that publication (false positive). False negatives can result from spelling variants or errors or name changes (e.g., due to marriage; Smalheiser & Torvik, 2009). False positives mainly result from homonymic names: names shared by multiple persons.

In our study, we are mainly concerned with false positives due to homonyms, as they erroneously lengthen a doctorate recipient's publication career. False negatives due to spelling variants and errors, are less problematic, because we are interested in the *first* publication and the publication career *spans* of these doctorate recipients. Missing publications only affect the year of first publication if a person's first publication happens to be missed and a doctorate recipient published only one paper in that year. They only affect publication career spans if a person's last publication is missed. As such false negatives due to spelling variants and errors occur randomly, they do not bias our results. Only in the case that doctorate recipients start publishing under a different name, will missing publications result in a shorter publication career than they have actually had. This may occur for women that get married or divorced after their first publication and publish under a different name after this marriage or divorce. Unfortunately, we cannot correct for this in our data, and it is difficult to estimate its precise effect. Several factors could have been at play and have had opposing effects. First of all, the share of women has increased over time (Thurgood, Golladay, & Hill, 2006). We measured how much this share increased in our dataset using gender assignment of the first names of doctorate recipients (as described in Sugimoto, Larivière, Ni, Gingras, & Cronin, 2013; Table S1). This is likely to have led to more false negatives over time. In addition, women marry later in life, which also leads to more false negatives over time (United States Census Bureau, 2012). However, this only occurs if they also change their name on publications when they get married, which we expect them to do less in recent times than fifty to sixty years ago (Goldin & Shim, 2004). This leads, in turn, to fewer false negatives. Finally, marriage rates have fluctuated over the course of the study period (Olson, 2015), so the number of women doctoral students and doctorate recipients to have gotten married *at all* will have fluctuated, too. This makes it difficult, if not impossible, to estimate the overall effect of longitudinal trends in gender and name changes on false negatives in our study.

There are several options for constructing a dataset of doctorate recipients and the papers they have authored: manual homonym disambiguation of the papers authored by the entire group of doctorate recipients, manual disambiguation of a sample, automatic disambiguation, or restricting the sample to authors with unique names. The first, manual disambiguation of the entire group, was impossible due to the large number of doctorate recipients in our study. The second would have been practically feasible but still very time-consuming. Furthermore, manual disambiguation is likely to be easier for more recent doctorate recipients, as they may be more traceable online. It is therefore likely that incorrect attribution would be more prevalent for the early group of doctorate recipients, which could introduce a bias in longitudinal analyses. The third option of automatic disambiguation heavily relies on "seed" publications (publications that one is sure are authored by the researcher, e.g., Reijnhoudt, Costas, Noyons, Börner, & Scharnhorst, 2014; Wooding, Wilcox-Jay, Lewison, & Grant, 2006) or on email addresses for disambiguating very common names (e.g., Caron & van Eck, 2014). For this study, we do not know which publications are unambiguously authored by a doctorate recipient (in fact, we do not know if they even *have* authored a WoS-indexed publication) and publications authored before 2004 do not have email addresses, so automatic disambiguation would be difficult, if not impossible.

Therefore, we decided to use a pragmatic approach by restricting our analysis to authors with unique names. Such an approach has also been followed by Boyack and Klavans (2008), *inter alios*. This approach has the advantage that it makes matching of author names from ProQuest to papers in the WoS possible while still obtaining unbiased results, as it is unlikely that a person with a unique name would behave any differently from a person with a common name. Below, we describe how unique names were selected.

4.2.2.2. Selection of unique names

Variation in surnames and combinations of surnames and initials varies by country. For example, the ten most frequent surnames in the U.S. and Norway account for less than 5% of the population, whereas in Korea the distribution is more skewed (Aksnes, 2008; Hanks & Tucker, 2000). When including initials, names become much more unique. In Norway, 86% of publishing researchers have a unique combination of surname plus initial(s), whereas only about a third of researchers in the Canadian province of Québec have a unique combination (Aksnes, 2008; Larivière & Macaluso, 2014).

In order to reduce the likelihood of homonyms, we selected names of doctorate recipients that occurred only once in ProQuest. This means that doctorate recipients from linguistic and cultural groups that have a larger share of common names (e.g., from Eastern Asia; Aksnes, 2008) are likely to be underrepresented in our sample. A further selection criterion to reduce the likelihood of homonyms was to only select names with two or three initials (Milojevic, 2013). As a next step, surnames occurring commonly in the Web of Science were removed (i.e., for each surname the number of distinct combinations of surname and initials was counted, and surnames occurring in 100 or more combinations were removed). Finally, we removed names of researchers with publications in fields distinct from that of the PhDs, as such publications suggests these names are homonyms. However, it would be too restrictive to remove all names with publications outside the precise field of PhD: many researchers publish in adjacent fields. Therefore, only the names with publications outside the broader research field were removed. In Table S2 (appendix 3) we show how we defined the broader research field for each group of doctorate recipients.

4.2.2.3. Retrieval of papers

Unique names in the ProQuest database need not be unique in the much larger WoS database. Therefore, further criteria were imposed on the retrieval of papers from this database. They concern several dimensions: the type of papers, the period for which papers were retrieved, the year of first publication, and the field of publication.

The type of paper was limited to "articles" or "reviews" as we are interested in measuring the research output of doctorate recipients. Papers published between five years before PhD and thirty years thereafter were retrieved. This period was chosen because publications published long before the PhD (e.g., ten years before PhD), or many years after (e.g., sixty years after) are unlikely to be authored by the doctorate recipient. In some cases, a thirty year limit might be too restrictive; however, in our main outcome measure, the span of the research career after the PhD, all publishing for over twenty years is considered to be a "life-long" career. As a further selection criterion a doctorate recipient's first publication must be between five years before and three or five years after PhD graduation; three years for astrophysics, chemistry, and genetics; five years for economics and psychology as PhD graduates in these fields publish their first paper later than in the other three fields (see the results section on year of first publication). In addition, at least one publication must be in the (narrow) field of their PhD. The tables of selected doctorate recipients and their publications used for the analyses of publication careers were constructed using the version of the WoS database of 2 October 2015.

4.2.2.4. Robustness of unique name selection

The robustness of the selection of unique names was tested by determining the effect of each selection step on the number of excluded doctorate recipients (Fig. S4) and on the *mean* number of papers published by the doctorate recipients. This analysis showed that the main effect on both the number of doctorate recipients and the mean number of publications came from the very first selection step: selection from the entire set of U.S. doctorate recipients to only those with a name that is unique in ProQuest. Subsequent steps of taking only doctorate recipients with two or three initials, with a surname that is not very frequent in the WoS, with a name that does not have publications in a disparate domain, and a first publication too long after the year of the doctorate did reduce the number of included doctorate recipients and their mean number of publications, but not by as much as the first selection step. The fact that the first selection step heavily reduced the mean number of publications indicates that this was the main step by which homonymic names were removed. With the subsequent selection steps, we further refined our selection. After the final selection step, the sample consisted of 30% of U.S. doctorate recipients in astrophysics, 30% in chemistry, 26% in economics, 29% in genetics, and 30% in psychology. These shares were quite stable in all fields, except for economics, where the share went down from 30% in the 1960s to 19% in 2006-2010 (Table S3).

4.2.2.5. Statistical analysis

Statistical analyses were performed in R i386 3.2.3 using the packages `stats` for Kruskal Wallis rank sum tests and `glm` for logistic regression. The package `ggplot2` was used to make figures.

4.3. Results

4.3.1. Share of doctorate recipients with one or more publications

First, we investigated the share of doctorate recipients with one or more publications. Figure 1 shows the shares of doctorate recipients who have published at least one paper, by year of PhD (in five-year time periods). There are large variations by discipline, with economics at the low end (25% over all time) and astrophysics at the high end (69% over all time; Fig. 1). This suggests that the entrance into the scholarly communication system by doctorate recipients in the U.S. varies heavily by field, with publishing being the norm in astrophysics, chemistry and genetics, but not in economics (Larivière, 2012). The proportion of doctorate recipients associated with publications has not, however, remained stable across time. As shown, rates have declined in astrophysics, economics, and psychology, have risen in genetics, and have fluctuated over time in chemistry.

A possible explanation for the fact that in three of the five fields the rates declined could be that admission into doctoral programmes may have become less selective as the number of doctoral enrollments grew. The increase in chemistry, economics and psychology from 2001 may have been of a more methodological nature: as shown in the Data and methods section, the number of journals indexed in the WoS grew in these disciplines, thereby increasing the chance of doctorate recipients in these fields to publish a paper indexed in the WoS.

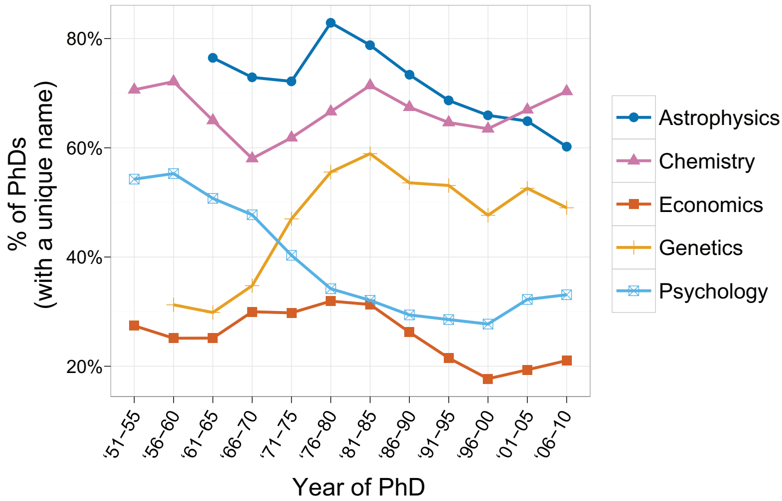

Figure 1. Percentage of doctorate recipients with at least one publication (datapoint only shown when number of doctorate recipients with a unique name in a given period > 100).

4.3.2. Year of first publication

Year of first publication illuminates important trends in scholarly communication behaviors of doctoral students. For the U.S. doctorate recipients who published at least one article, we determined when they published it relative to when they received their PhD (Fig. 2). As shown, in all fields except economics the year of first publication has shifted to before conferral of the PhD. The clearest shifts were observed in chemistry, genetics, and psychology: in the 1951-1960 period the median first publication was in the year of PhD or one year after, and in the 2001-2010 period, the median is one or two years *before* PhD. Only in economics did the relative year of first publication not change, remaining at two years after the doctorate.

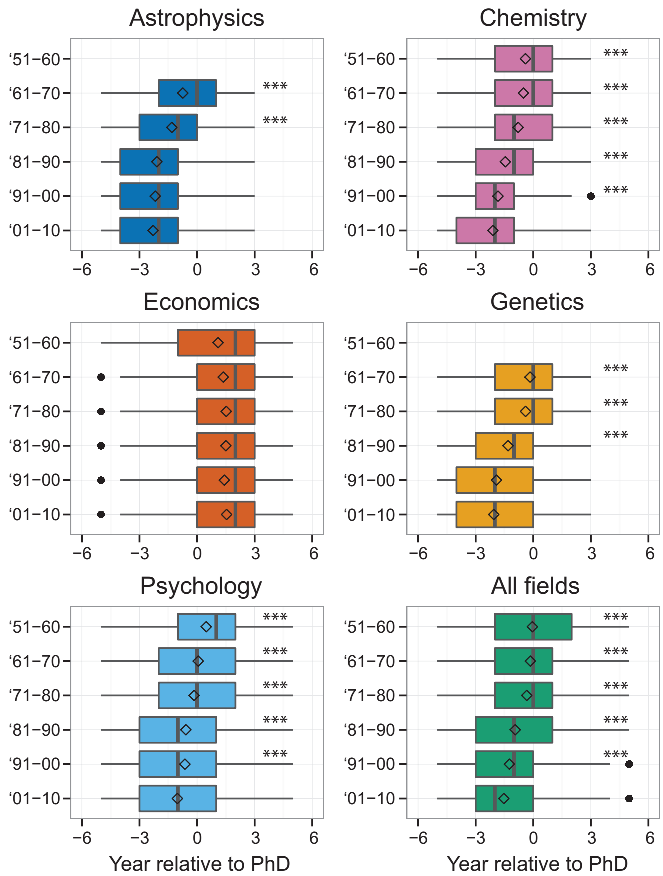

Figure 2. First publication relative to the year of PhD. For doctorate recipients with at least one publication, the relative year of their first publication was determined (with 0 being the year of PhD). Relative year of first publication is plotted by year of PhD (in ten-year periods; only plotted when number of doctorate recipients with at least one publication in a period > 50). The diamond represents the mean relative year of first publication. The selection of doctorate recipients was restricted to having a first publication between five years before and three years after PhD (astrophysics, chemistry and genetics) or between five years before and five years after PhD (economics and psychology; see Data and methods section).

4.3.3. Post-PhD career spans of doctorate recipients

Post-PhD career spans of U.S. doctorate recipients we examined by computing the share of recipients publishing at various career lengths: up to two, three to five, six to ten, eleven to fifteen, sixteen to twenty, and twenty to thirty years since the doctorate. We consider the publication career spans of the 1951-2010 doctorate recipients, with papers published after a long interruption in publication (five years or longer) removed (Fig. 3). In such an investigation, no distinction can yet be made between post-1985 doctorate recipients with a short publication career and those whose publication careers have been interrupted but who will later resume publishing. For example, a scholar receiving a PhD in 1990 could have published his or her last paper in 1995, which means a career span of five years. However, he or she could publish a next paper in 2017, which would mean their career span would actually be 27 years. With our current data we naturally cannot measure 2017 publications. However, when papers published after an interruption are disregarded, the determination of post-1985 doctorate recipients' publication career length can be performed. Results for a publication career category are only shown when all doctorate recipients in a five-year period have been followed for the entire span of the publication career category. An example: for 1986-1990 doctorate recipients, we do not plot the shares of doctorate recipients publishing for >20 years after PhD, because these recipients should then have been followed from the year of PhD until 2016 to 2010 (as the >20 years category is comprised of persons publishing for 20-30 years since PhD). Hence, the shares do not add up to 100%.

The main change in publication career length has been in the shares of doctorate recipients without any publications (Fig. S5), especially in astrophysics, psychology (where this share has increased), and in genetics (where it has decreased). As these shares are often quite high, it is difficult to study trends in the publication careers of publishing doctorate recipients. Furthermore, it is difficult to conclude whether increasing or decreasing shares of certain career spans are due to a relative lengthening or shortening of career spans, or due to changing shares of publishing doctorate recipients. Therefore, in our further analysis of career spans, we disregard doctorate recipients who have not published at all.

These results show that the share of doctorate recipients with a long publication career (over twenty years) is quite large, especially in astrophysics and genetics: about 40%. This share is lower in chemistry (about 20%), economics (between 5 and 20%), and psychology (between 15 and 20%).

Looking at trends in the spans of publication careers, in astrophysics, chemistry, genetics and psychology, the share of doctorate recipients with long publication careers has remained quite stable, but increased in economics. The share of intermediate length careers (6-20 years) decreased in psychology in the late 1980s and the 1990s. With respect to the share of brief publication careers, in chemistry, recent decades have seen a slight upward trend after an initial decline. In astrophysics, these shares increased from the 1970s to the 2000s, and in psychology, they increased from the 1950s until the 2000s, Conversely, in economics, there was a downward trend. To further investigate the probability of doctorate recipients having a short publication career, we predicted the probability of having a publication career lasting up to five years since PhD for 1951-2005 doctorate recipients, using a logit regression. The dependent variable was the dichotomous variable "publication career <=5 years", and the independent variables were year of PhD, field and an interaction term between the two. The predicted probabilities show that in all fields except economics, the probability of having a short publication career increased (Fig. 3, bottom right panel). This shows that, although the span of publication careers remained relatively stable during the investigated period, the share of doctorate recipients with a short publication career slightly increased (except in economics). However, here it must also be noted that the positive slopes are in part due to the low numbers of doctorate recipients in earlier decades of our study, which thus have a small effect in the regression. For example, the slope of genetics is positive, although the shares of doctorate recipients with a short publication career (Fig. 3, genetics panel) were actually larger in the 1950s and early 1960s than later. It is due to the small numbers of doctorate recipients in this period and the larger numbers later that the slope is positive.

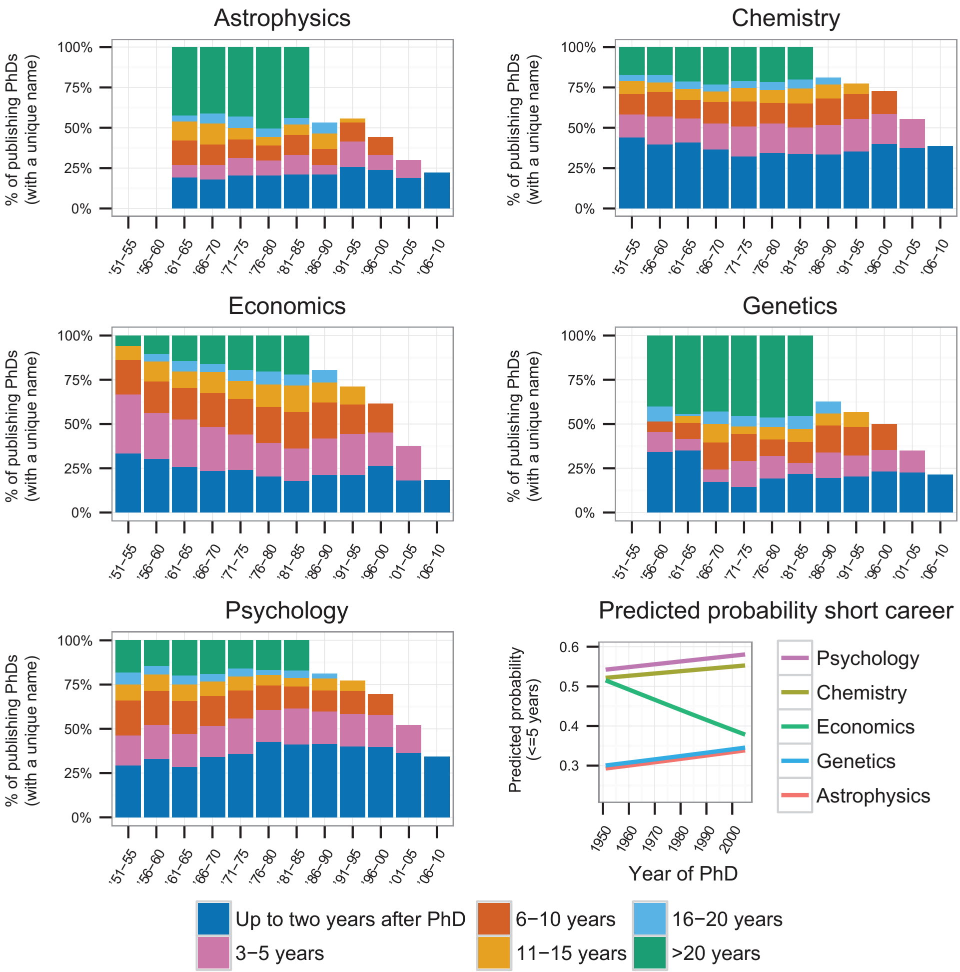

Figure 3. Career length by five-year period and field. Papers published after publications interruptions of over five years removed (only plotted when number of doctorate recipients with one or more published papers in a five-year period > 25, and when all doctorate recipients in a five-year period have had the opportunity to publish in a given period; see footnote 2).

4.4. Discussion and conclusion

The large growth in the number of doctoral students compared to a smaller growth in tenure track positions has raised concerns in the scholarly community ("Indentured labour", 2007; "Make the most of PhDs", 2015; Pavlidis et al., 2014; Petersen et al., 2014). In a recent article, Ioannidis et al. (2014) argued that the current academic career system is recruiting too many doctoral students without being able to offer them long-term careers, and is in fact exploiting them. This conclusion is supported by the fact they found only 1% of the scientific workforce to be continually publishing. We investigated whether the changes in academic employment have replaced long investigative careers with more volatile ones, and whether publication practices during the doctoral training period have changed.

We find that the proportion of publishing doctorate recipients has changed through time, but that this trend differs by field: in astrophysics, economics and psychology the proportion went down, in chemistry it remained quite stable, and in genetics it went up. Furthermore, the share itself varies by field; it is highest in astrophysics and lowest in economics. This difference is probably due to the nature of the fields. In the natural and life sciences, research is usually conducted in larger teams than in the social sciences, and graduate students granted authorship as the result of their role in such teams (Larivière, 2012; Petersen et al., 2014).

The span of publication careers also varies by field, a finding also very likely to be related to the nature of the various fields. In the basic research fields of astrophysics and genetics many doctorate recipients continue to publish scientific findings for a long time. In contrast, in the professional and more applied fields of chemistry and psychology, doctorate recipients are more likely to find non-academic employment, leading to shorter publication careers. In economics, a field we characterized as more academic than psychology in our Data and methods section, publication careers are only slightly longer than in psychology. This may be due to the fact that we did not include articles published more than five years apart; as productivity levels in economics are lower than in the natural sciences, it is more likely that academic papers are published more than five years apart (Larivière, 2012).

At the same time, the time of doctoral recipients' first publication has shifted. In astrophysics, chemistry, genetics and psychology the year of first publication shifted from after the PhD to several years before the PhD. Only in economics did the first publication year remain stable. Several factors may explain this trend, such as research groups shifting their research tasks and activities from scientists with a PhD to those without, indicating an increasing reliance on doctoral students for the production of knowledge (Rothman, 2014; Stephan, 2012, pp. 68-69; "The disposable academic", 2010). Another reason is an increasing focus on publication as part of PhD students' so-called "socialization" to the world of research (Kamler, 2008). Finally, the increasing rates of collaboration in science may have led to more doctoral students being granted authorship on research conducted together with more senior colleagues (Gazni, Sugimoto, & Didegah, 2013; Larivière, Gingras, Sugimoto, & Tsou, 2015).

Going back to the question whether the relative decline of tenured and tenure track positions led to shorter investigative careers, our results show this is not truly the case. Although the probability of shorter careers has increased to a slight extent, the span of the publication career has remained quite stable (in astrophysics, chemistry, genetics, and psychology) or even increased (in economics). Furthermore, in the basic research fields of astrophysics and genetics, long publication careers (of over twenty years) have been the most common career for doctorate recipients from the early 1950s to the early 1980s. These findings seem to be at odds with the findings of Ioannidis et al.'s study of the share of scientists publishing one or more papers every year and Petersen et al.'s study of career longevity in high-profile journals (Ioannidis et al., 2014; Petersen, Jung, Yang, & Stanley, 2011). These differences in findings are likely due to the fact that we did not restrict our sample to scientists publishing every year but included scientists publishing once in five years. Most importantly, our selection of scientists differs from that of Ioannidis and colleagues. They look at *all* authors with a publication in the bibliographic database Scopus, which also includes technicians and undergraduate students. In contrast, we look at people who have received a PhD. This degree qualifies them for an academic position that enables them to have a longer publication career. Petersen et al. found that most authors have a very short publication career in high-profile journals (Petersen et al., 2011). However, as these authors also indicate, the publication career span of a scientist in a particular top tier journal is not the same as the entire career span of a scientist, which explains our dissimilar findings.

When interpreting our findings, it must be borne in mind that our findings are based on an analysis of the publication careers of doctorate recipients with rare names. As already noted earlier in the paper, this means doctorate recipients with common names are not included in the analysis, which is likely to lead to an underrepresentation of doctorate recipients of East Asian origin (primarily Chinese and Korean).

In conclusion, not only are long publication careers common, the shares of more recent doctorate recipients publishing for a short period after the PhD are also stable. Therefore, while employment structures may have changed, the span of research activity by doctorate recipients has not. So in what types of positions do these academics work? Data on academic positions show a large increase in the number of postdoctoral positions (Cantwell & Taylor, 2015; Hill & Einaudi, 2010). This rise is due to both an increase in the number of recent doctorate recipients taking a first postdoctoral position and an increase in the time spent in postdoctoral positions (Stephan & Ma, 2005). In addition, the number of non-tenure track staff positions has increased through time (Schuster & Finkelstein, 2006, pp. 193-195). Our results show researchers have publication careers that are as long as they were before. However, they may be in "holding positions" or on "soft money" (i.e., postdoctoral and non-tenure track positions) for a much longer time. In addition, they may have continued publishing in non-academic employment, although through time, the importance of industrial laboratories in basic research has actually decreased rather than increased, making this unlikely (Vardi, 2015).

This leaves one final question: why were doctorate recipients not deterred by the relative lack of tenured and tenure track positions and did they continue to publish for the same length of time? The replacement of tenured and tenure track positions with short (postdoctoral) contracts lead to a larger effect of chance on academic career spans (Petersen, Riccaboni, Stanley, & Pammolli, 2012). And one would expect diminished career prospects to lead to decreased attractiveness of science and more individuals opting to work outside science. Possibly, this is because the rewards are high if one *does* succeed at landing a tenured position, and one can then supervise and advise many junior researchers—the so-called "pyramid structure of science" (Stephan, 2012, pp. 70-71). Another reason may be the job characteristics that science offers. U.S. doctoral students expect academia to offer more freedom than industry (Roach & Sauermann, 2010) and doctorate recipients in the Netherlands and Denmark are attracted to academia because of the intellectual challenge, independence, and creativity offered, even though academia offers less job security (Bloch, Krogh Graversen, & Skovgaard Pedersen, 2015; Waaijer, 2016). As such, the attractive force of science, in combination with the large rewards at the top of the career ladder, may enable science to retain comparable numbers of practitioners despite diminished career prospects.

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PART III

Effects of career prospects and employment conditions on early career researchers

CHAPTER 5

Perceived career prospects and their influence on the sector of employment of recent PhD graduates

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Abstract

We studied the perception of career prospects in their own sector and elsewhere of recent PhD graduates in academia, non-academic research and outside research. Data are from a survey of 1,133 respondents who obtained a PhD from one of five Dutch universities between early 2008 and mid-2012. Career prospects in academia are seen as slimmer than outside. This is associated with the current sector of employment: outside academia the negative image of academic careers is still stronger than inside. This association remains when other factors, such as the appeal of certain job attributes and several personal characteristics are controlled for. The chance that PhDs seek employment outside academia because of career prospects depends on how they value positive job aspects, such as intellectual challenge. This leads to selection against certain types of PhD graduates in academia, such as those with a taste for societal impact.

5.1. Introduction

As in many countries, the number of PhD graduates from Dutch universities has been increasing over the past ten years (Auriol, Misu, & Freeman, 2013; Vereniging van Nederlandse Universiteiten, 2014). For many PhD students, academic research is the preferred sector of future employment (Sauermann & Roach, 2012). However, in the U.S. only up to twenty-five per cent of PhD graduates will obtain a (permanent) faculty position (Stephan, 2012, p. 170), and in the Netherlands fewer than thirty per cent of all PhD graduates work in higher education (Auriol et al., 2013, p. 19).

PhD graduates in the United States can spend up to ten years in temporary postdoctoral positions before obtaining a faculty position (Nerad & Cerny, 1999). For PhD graduates in the Netherlands this also holds true (van Balen & van den Besselaar, 2007). Furthermore, a survey of PhD students and postdoctoral researchers in Germany, Austria and Great Britain shows that these early career scientists report high levels of insecurity about their careers (Höge, Brucculeri, & Iwanova, 2012). The lack of permanent positions in academia and the long periods during which scientists are employed on temporary contracts are also regarded as a problem by opinion makers in *Nature* and *Science* editorials, as they make an academic career less attractive to young researchers (Waaijer, 2013). However, no studies have previously been undertaken that relate the perception of career prospects and actual sector of employment of PhD graduates.

In this study we determine how recent PhD graduates rate several dimensions of career prospects in the academic sector, in non-academic R&D and outside R&D, such as the long-term career perspectives in general, availability of permanent positions, and the quality of career policy. Furthermore, we investigate whether this perception of career prospects is related to the sector in which these PhD graduates work. In the final section we discuss the implications of our findings for the effectiveness of the academic career system.

5.2. Literature background

5.2.1. Post-PhD employment internationally

Since 1957, the National Science Foundation (NSF) has conducted an annual survey of new U.S. PhD graduates, the Survey of Earned Doctorates (SED; National Science Foundation/ National Center for Science and Engineering Statistics, 2014a). This survey collects several characteristics of PhD graduates and their post-graduation plans. Furthermore, the NSF conducts a biennial survey of all PhD graduates from U.S. research universities, called the

Survey of Doctorate Recipients (SDR; NSF/NCSES, 2014b). The 2013 survey showed that directly after PhD, most PhDs work in academia: seven in ten PhDs work as postdoctoral fellows or in academic employment (NSF/NCSES, 2014b, Table 52, own calculations[1]). However, this share declines with the time elapsed since PhD graduation. Of all PhDs, slightly more than four in ten are employed in academia (NSF/NCSES, 2014b, Table 12). Other important sectors of employment include private for-profit organizations (employing one third of PhDs) and government (employing one in ten PhDs).

High quality, internationally comparable data on PhD graduates used to be lacking for other countries, but have become available for more countries with the implementation of the Careers of Doctorate Holders (CDH) survey. It has been carried out in 2006, 2009, and 2014 in the United States, Taiwan and several European countries (OECD, 2013). Although the quality and content of the surveys differed by country, for the Netherlands it provided the first high quality data on post-PhD employment.

5.2.2. Post-PhD employment in the Netherlands

In this paper, we focus on the Netherlands, a country in which the number of PhD graduations has only increased in the past decade (Auriol et al., 2013; VSNU, 2014, cf. for example the U.S., where the number of PhD graduates has fluctuated; NSF/NCSES, 2014a, Table 1). Opportunities for academic employment do not keep pace with this increase of PhD graduates (VSNU, 2015). This raises the question in which sector graduates find employment after their PhD, and what influenced their choice. Are recent PhDs primarily attracted by job attributes, or do the career prospects in a particular sector influence their choice as well?

For the Netherlands, the CDH found that just over twenty per cent of all employed PhD graduates are employed as a researcher in the higher education sector (Maas, Korvorst, van der Mooren, & Meijers, 2014, Table 21). Another six in ten are employed as researchers in another sector, which adds to a total of eighty per cent of all PhDs being employed as researchers. The remaining twenty per cent are employed as non-researchers, of which most are working in the private non-profit sector. Compared to other countries, the Netherlands have a high share of PhDs working outside of higher education; the highest of all countries surveyed in the CDH (Auriol et al., 2013, p. 19). For the Netherlands, the 2008 Netherlands Survey of Doctorate Recipients found that directly after the PhD, sixty-four per cent are employed in academia (Sonneveld, Yerkes, & van de Schoot, 2010). The current study is a follow-up of this survey.

[1] Numbers of PhD graduates who have a definite commitment to postdoctoral study or academic employment in the U.S. divided by the total number of PhDs of whom the sector of definite commitment is known.

5.2.3. Career prospects in academia and other sectors

Here, we define career prospects as the chance of (future) success in a profession. This future success may entail many different aspects, such as employment versus unemployment, level of education required for a job, salary, obtaining a job of the first choice, obtaining a permanent position, etcetera. The percentage of PhD graduates who are economically active is slightly higher than for other university graduates, and among the economically active, unemployment is low (Statistics Netherlands, 2014). As to salary, the advantage of having a PhD on the labor market varies by country. Stephan (2012, pp. 156-157) compared the estimated lifetime earnings of a PhD in the biological sciences to a Master of Business Administration (MBA) degree, and found that the lifetime earnings of PhDs are much lower. On the other hand, estimated lifetime earnings of PhDs in the Netherlands are higher than of master graduates, though it takes twenty years to achieve a positive rate of return on doing a PhD (van der Steeg, van der Wiel, & Wouterse, 2014). In addition, during a PhD several types of knowledge and skills that are useful in future careers may be acquired (Lee, Miozzo, & Laredo, 2010).

Still, many scientists, journalists and policymakers write about bleak career prospects after a PhD, especially within academia (e.g., Cyranoski, Gilbert, Ledford, Nayar, & Yahia, 2011; "The disposable academic", 2010; Weissmann, 2013; see Waaijer, 2013 for a detailed discussion). However, few systematic examinations of the perception of career prospects of PhDs have been conducted. One exception is a study by Fox and Stephan (2001) that examined how PhD students in science and engineering perceive their career prospects. They found that PhD students judge career prospects in academia as poorer than in industry and government. The availability of jobs after a PhD in science and engineering is more positively perceived for industry employment than for faculty positions (Roach & Sauermann, 2010). Finally, a survey of PhD students at Leiden University found that a majority think finding employment in academia or research will be (very) difficult, more so than finding employment outside of academia and research (Heyer, Kuli, Vis, & Waaijer, 2013, p. 40).

In Australia, long-term career prospects in academia are perceived more positively by postdoctoral fellows (Åkerlind, 2005). In Germany, a detailed study of career prospects showed that postdoctoral fellows perceive the competition for a successful academic career in their field as (very) strong, but do assess their own prospects to pursue such a career as rather good (Fitzenberger & Schulze, 2014). Furthermore, the study showed that postdoctoral fellows judge their employment prospects in jobs outside academia rather positively, but also assume these prospects will worsen if they continue to work in academia.

5.2.4. Factors influencing job choice of PhD graduates

Several factors may influence the job choice of PhD graduates. First of all, PhDs may have personal preferences for certain job attributes. For many PhD students, academia is the preferred sector of employment. This sentiment is arguably even stronger for postdoctoral fellows, who have already made an initial decision to work in academic research (Fitzenberger & Schulze, 2014; Puljak & Sharif, 2009). Features of academia and research in industry differ due to divergent purposes and reward systems (Dasgupta & David, 1994). Having a "taste for science" (i.e., valuing intellectual challenge, work circumstances, independence, and contribution to society) and having a preference for academia have been found to be correlated in several studies (Bloch, Krogh Graversen, & Skovgaard Pedersen, 2015; Roach & Sauermann 2010). The non-pecuniary rewards such as, for example, higher levels of freedom and intellectual challenge, thus offset the lost pecuniary rewards related to a job in industry (Agarwal & Ohyama, 2013; Janger & Nowotny, 2013; Stern, 2004). On the other hand, PhD graduates who value access to resources have a greater preference for employment in industry (Roach & Sauermann, 2010) and those who have a "taste for business" (i.e., valuing salary, benefits, career progression, and job security) have a higher probability of actually working in industry (Balsmeier & Pellens, 2014).

In addition, the (perceived) availability of jobs in a given sector may play a role. We incorporate this factor in our analysis, although it must be noted that in previous studies on the job preferences and job choices of PhDs, its effect has been found to be limited: Roach and Sauermann (2010) found no effect of the perceived availability of academic positions on the preferred employment sector, and Bloch et al. (2015) found little effect of actual industry labor demand on sector of employment. Other factors that may play a role are field of PhD (field of PhD may determine the number of available jobs in different sectors, and PhDs from one field may value different job characteristics than PhDs from another field), years since PhD (as this may affect the number of available jobs) and personal characteristics.

5.3. Material and methods

5.3.1. Sample and survey methodology

Two sources of PhD graduates were used as a sample for our survey. The first was the survey sample of the 2008 Netherlands Survey of Doctorate Recipients (Sonneveld et al., 2010). This survey was sent to close to 1,100 individuals obtaining a PhD between April 2008 and March 2009 at Utrecht University (a large, broad research university), Delft University of Technology (a university of technology), Wageningen University (a university focused on agricultural, environmental and life sciences), and Erasmus University Rotterdam (focused on medicine and social sciences, especially economics and management). The second source of PhD graduates in the present study were all individuals who obtained their PhD at Leiden University (a large, broad research university) between January 2008 and May 2012: a total of 1,319 PhD graduates. This amounted to a total of 2,410 PhDs, of which 2,193 could be contacted (see Waaijer, Belder, van Bochove, Sonneveld, & van der Weijden, 2015 for a complete description of the survey distribution). PhDs were contacted regardless of whether they were working inside the Netherlands or outside of it. The five universities and its PhD graduates cover all major research fields: medical and health sciences, natural sciences, social sciences, humanities and engineering. The survey was open from 23 October 2013 until 21 January 2014. During this period a total of three reminders was sent to potential respondents who had not visited the survey or not completed it.

Of the 2,193 sample, 1,133 PhDs started our survey, a response rate of 51.7%. A total of 960 progressed to the final question (43.8%). A comparison of the characteristics of the respondents and the 2,410 PhDs in the complete set shows that the respondents are a good representation with regards to year of PhD, city of PhD, gender, and age (Waaijer et al., 2015). However, there is an overrepresentation of Dutch nationals compared to other nationalities among the respondents.

5.3.2. Variables

Our questionnaire contains mainly multiple-choice questions but also a small number of open questions. Questions cover employment status, job choice, perception of career prospects, job satisfaction, use of skills developed during the PhD, and mentoring during the career. In this paper, we will focus on the first three aspects. The complete questionnaire can be consulted in Waaijer et al. (2015).

5.3.2.1. Sector of current employment

The main dependent variable is the sector of current employment. We distinguish three sectors: academic R&D (further dubbed "academia" for brevity), non-academic R&D ("non-academic research"), and non-R&D ("outside research"). This distinction requires some elaboration. It is modeled after a further partition of categories that has been used in most studies on factors influencing post-PhD employment (academia vs. industry employment; e.g., Balsmeier & Pellens, 2014; Roach & Sauermann, 2010) and is more similar to the five categories distinguished by Bloch et al. (2015). Arguably, PhDs who perform research (or experimental development) in non-university settings still use skills they were mainly trained in during their PhD. On the other hand, some PhDs are no longer involved in R&D. In the Netherlands, two in ten of all PhD graduates do not work as researchers (Maas et al., 2014).

Table 1. Variable definition and descriptive statistics

Variable			Type	N	Mean	SD	Min	Max
Sector of employment	Academia		Dummy	1024	0.60	0.49	0	1
	Non-academic research		Dummy		0.28	0.45	0	1
	Outside research		Dummy		0.12	0.32	0	1
Perception of career prospects	Long-term career perspectives	Academia	5-point	859	2.90	1.17	1	5
		Non-ac. research	5-point	733	3.39	0.92	1	5
		Outside research	5-point	697	3.48	0.91	1	5
	Availability of permanent positions	Academia	5-point	864	2.19	1.12	1	5
		Non-ac. research	5-point	712	3.05	1.01	1	5
		Outside research	5-point	680	3.31	0.98	1	5
	Length of period holding temporary positions	Academia	5-point	748	2.61	1.04	1	5
		Non-ac. research	5-point	528	3.13	0.84	1	5
		Outside research	5-point	503	3.26	0.81	1	5
	Quality of HRM/career policy	Academia	5-point	717	2.71	1.01	1	5
		Non-ac. research	5-point	491	3.26	0.87	1	5
		Outside research	5-point	457	3.32	0.81	1	5
(Self-reported) influence of career prospects	Long-term career perspectives	Academia	5-point	947	3.37	1.25	1	5
	Availability of permanent positions	Academia	5-point	940	2.97	1.35	1	5
	Length of period holding temporary positions	Academia	5-point	926	2.63	1.30	1	5
	Quality of HRM/career policy	Academia	5-point	929	2.31	1.21	1	5
Factors playing a role in job choice	*Job content and intellectual development*							
	Creativeness		Dummy	1016	0.62	0.49	0	1
	Intellectual challenge		Dummy	1017	0.83	0.38	0	1
	Level of responsibility		Dummy	1017	0.59	0.49	0	1
	Degree of independence		Dummy	1017	0.70	0.46	0	1
	Possibility to develop new skills		Dummy	1017	0.70	0.46	0	1
	Contribution to society		Dummy	1017	0.52	0.50	0	1
	Social status		Dummy	1014	0.21	0.40	0	1

	Workload	Dummy	1016	0.18	0.38	0	1
	Infringement on personal life	Dummy	1015	0.19	0.39	0	1
	Terms of employment						
	Salary	Dummy	1014	0.31	0.46	0	1
	Benefits	Dummy	1014	0.22	0.42	0	1
	Job security	Dummy	1014	0.33	0.47	0	1
	Availability of permanent jobs within organization	Dummy	1014	0.22	0.41	0	1
	Job opportunities within organization	Dummy	1014	0.23	0.42	0	1
	Organization's career policy and HRM	Dummy	1014	0.11	0.32	0	1
	Degree to which job provided opportunities for career advancement (also outside of organization)	Dummy	1014	0.48	0.50	0	1
	Travelling distance from home to job	Dummy	1015	0.28	0.45	0	1
	Personal and family-related circumstances	Dummy	1014	0.22	0.41	0	1
Availability of jobs	Sufficient positions available in preferred sector of employment	5-point	1025	3.03	1.17	1	5
Years since PhD		Count	1133	3.97	1.24	1	5
Field of PhD	Medical and health sciences	Dummy	1065	0.34	0.47	0	1
	Natural sciences	Dummy		0.26	0.44	0	1
	Social sciences	Dummy		0.17	0.37	0	1
	Humanities	Dummy		0.13	0.33	0	1
	Engineering and technology	Dummy		0.11	0.31	0	1
Personal characteristics	Female	Dummy	1096	0.45	0.50	0	1
	Nationality of high income OECD country	Dummy	875	0.90	0.29	0	1
	Age at PhD	Count	1101	34.10	7.50	11*	69
	Married or living together?	Dummy	938	0.79	0.40	0	1
	Children below the age of 6	Dummy	935	0.40	0.49	0	1

Dummy variables: 1 if yes, 0 if no. Perception of career prospects on a five-point scale from 1=very bad to 5=very good; "don't know" values were removed. Influence of career prospects on a five-point scale from 1=not at all to 5=very much or very strongly. Sufficient positions available in preferred sector of employment on five-point scale from 1=strongly disagree to 5=strongly agree with statement. Age at PhD calculated by subtracting year of birth from year at PhD. Years since PhD calculated by subtracting year of PhD from year at filling in survey. Two resultant values were very low ("11" and "21") and are assumed to be outliers and excluded from further analyses with age at PhD as a variable.

5

This is the reason we classified the PhDs according to the two criteria “involvement in R&D” and “type of employer”, leading to the three sectors introduced above.[2] To obtain the needed information, PhDs were asked whether they were involved in basic research, applied research and/or experimental development in their main job (following OECD definitions [OECD, 2002, pp. 77-82]). If they were not, they were classified as working outside research. If they were, a further distinction according to type of employer was made; if the employer was a university, university of applied sciences or college, academic hospital, or research institute, we classified PhDs as working in academia. Researchers and engineers working elsewhere (e.g., at a private business, government institution, or non-academic hospital) were classified as working in non-academic research.

5.3.2.2. Perception of career prospects and their reported influence

PhDs were asked to rate the career prospects in all three sectors on a five-point Likert scale (1=very bad, 2=bad, 3=neutral, 4=good, 5=very good, 99=don’t know). These were separated into: long-term career perspectives, the availability of permanent jobs, the usual length of the period holding temporary positions, and the quality of HRM and career policy. We asked the PhDs to what extent these factors had influenced their job choice. The influence was measured on a five-point scale (1=not at all, 5=very much).

5.3.2.3. Job attributes that have played a role in job choice

To determine which job attributes attracted the PhDs to their current job, we asked them to tick which attributes played a role in choosing their current job. These were roughly divided into job content and intellectual development (creativeness, intellectual challenge, level of responsibility, degree of independence, possibility to develop new skills, contribution to society, social status, workload, infringement on personal life), and terms of employment (salary, benefits, job security, job opportunities within the organization, availability of permanent jobs within organization, organization’s career policy and HRM, degree to which job provided opportunities for career advancement (also outside the organization), travelling distance from home to job, and personal and family-related circumstances).

5.3.2.4. Other variables

We also asked the respondents about other factors that might mediate job choice. These included the availability of jobs, years since PhD, field of PhD, gender, nationality, and age at PhD. Nationality is measured as a dummy with value one for high income OECD countries and zero for elsewhere (see appendix 4 for more details and a list of countries). This was done because exploratory analysis showed that PhDs with a nationality from high income OECD

[2] Bloch et al. (2015) also distinguished PhDs working in non-academic research and outside research by whether they were working in the public sector or in the private sector. Due to our smaller number of respondents we chose to distinguish three sectors instead of five.

countries were (much) more negative about career prospects in academia. The descriptive statistics of all variables from closed questions are shown in Table 1. Correlations are shown in Figure S1 (appendix 4).

Furthermore, we used the answers to the open question "Which long-term career prospects have been the most important in choosing your career, and why?". Answers were coded according to the variables from closed questions when possible, but also other codes were added when needed. The main classes we delineated for our analysis are career prospects, short-term job availability, career goals, personal circumstances, and job attributes. A second individual coded a random 10% sample of filled-in answers to assess inter-observer reliability. A description of our classification and coding rules is given in Table S1 (appendix 4).

5.4. Results and discussion

5.4.1. Perception of career prospects

In this section of the paper, we first look at how PhD graduates perceived career prospects in different sectors: academia, non-academic research, and outside research. The investigated dimensions are the long-term career perspectives PhD graduates envision for themselves, the availability of permanent positions, the usual length of the period holding a temporary position, and the quality of HRM and career policy. Respondents were asked to rate these dimensions on a five-point Likert scale, from very bad to very good. All dimensions were rated more negatively for academia than for non-academic research and outside research (Fig. 1; $p < 0.001$ for all items in Pearson's chi-squared test of independence). Long-term career perspectives were rated as "bad" or "very bad" for academia by more than forty per cent of respondents, whereas this figure was only fifteen for non-academic research and just over ten outside research. Academia was rated especially low regarding the availability of permanent positions: seven in ten respondents rated this dimension as "bad" or "very bad", whereas they were more positive about non-academic research and outside research. The same rating difference existed for the usual length of the period holding a temporary position, but more respondents were neutral about this dimension. Finally, the quality of HRM and career policy was again rated lower on average for academia, but many respondents held a neutral position. Our findings are similar to Fox and Stephan's (2001), who found that PhD students judge their career prospects in academia more negatively than prospects in industry and government. In relation to data on the employment of PhDs in the long run, which shows non-academic employment to be more common than academic employment (e.g., Lee et al., 2010; Maas et al., 2014), such judgments may not be unfounded.

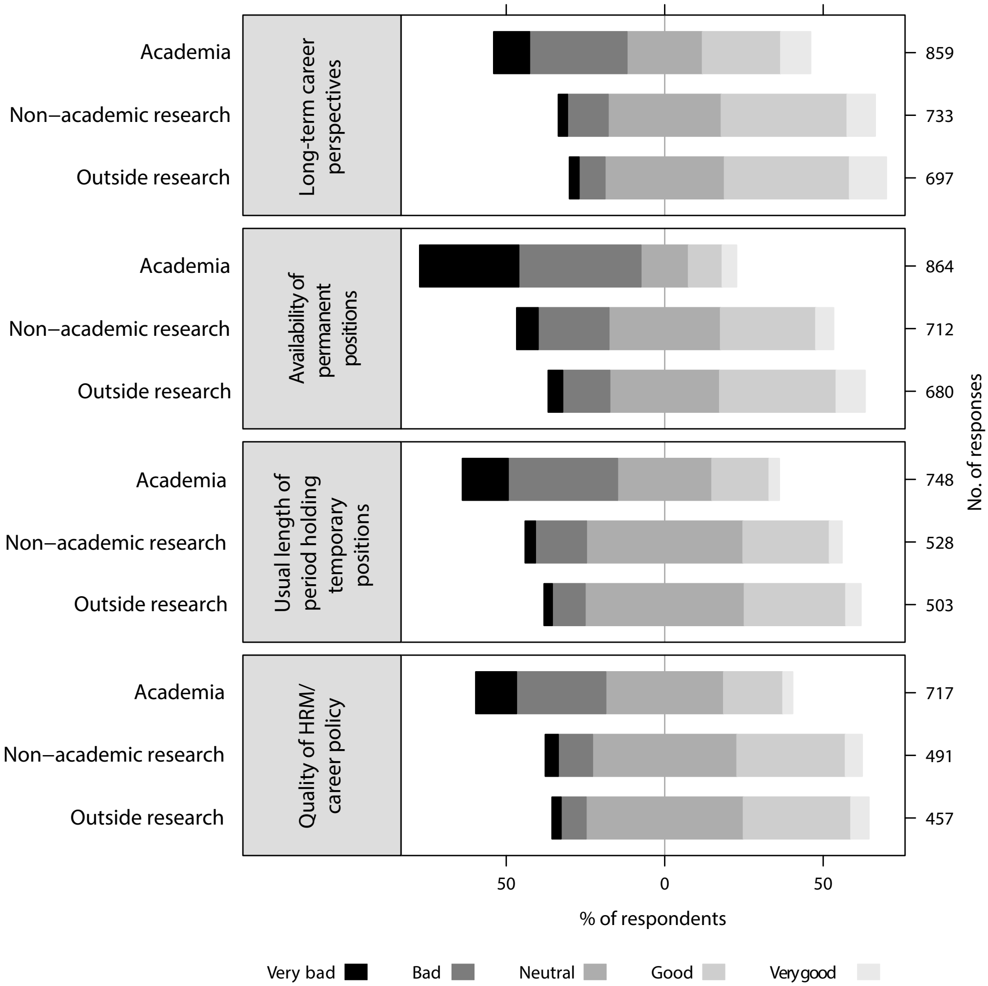

Figure 1. Perception of four aspects of career prospects in academia, non-academic research and outside research.

5.4.2. Self-reported influence of career prospects on job choice

These results raise the question whether a negative perception of career prospects in academia influences the job choice of PhD graduates: does it discourage them to aspire to a career in academia? To investigate, we put the question to our respondents to what extent the four different dimensions of career prospects in academia have influenced the choice for their current job. Furthermore, we assessed whether the strength of any such influence depended on the perception of career prospects.

The dimensions of career prospects that have influenced the PhDs' job choice predominantly are long-term career perspectives and the availability of permanent positions (Table 2). More than half of the respondents said they had been influenced "very strongly" or "strongly" by long-term career perspectives, and four in ten by the availability of permanent positions. In comparison, the usual length of the period of holding temporary positions and career policy played a lesser role, according to the respondents.

Table 2. Self-reported influence of career prospects in academia on job choice

Aspect of career prospects	Influence				
	Very strong	*Strong*	*Moderate*	*A little*	*Not at all*
			%		
Long-term career perspectives	19	34	25	10	13
Availability of permanent positions	15	24	26	13	22
Usual length of period holding temporary positions	8	19	32	11	30
Quality of HRM/career policy	4	12	30	16	37

N.B. Percentages may not add up to 100 due to rounding.

5

The extent to which career prospects in academia have influenced job choice differs by how positive respondents were about them. PhDs who were positive about the different dimensions of career prospects in academia reported a greater influence than those who are neutral or negative. Thus, there appear to be two situations. On the one hand, PhDs who were optimistic about career prospects in academia indicated they based their job choice on these prospects. On the other hand, PhDs who were pessimistic (the majority) tended to be less influenced by career prospects and appear to have based their job choice on other factors. If these pessimistic PhDs stayed in academia, there should be an "attractive force" of academia that makes its bleak career prospects relatively unimportant.

In the section after the next we will go into this attractive force in more detail. First, however, we will analyze whether the results presented in the current section on the influence of career prospects reported by the respondents themselves are confirmed by the PhDs' *actual* job choice. In other words, do PhDs who think negatively about career prospects in academia actually leave this sector to work elsewhere?

5.4.3. Influence of perception of career prospects on actual job choice

At the time of the survey, almost all respondents were had a job (Table S2 in appendix 4). Their main job was in academia for sixty per cent, in non-academic research for 28 per cent and outside research for 12 per cent (Table 1).

To determine whether the perception of career prospects influences job choice, one would ideally like to know what the PhDs' perception was at the precise moment that they decided on a new job. However, it is not feasible to ask for this information retrospectively, because memory effects would be likely to bias the reports to an unknown extent. Recalling attitudes is notoriously unreliable, especially if such an attitude was not remembered consciously (Smith, 1982), and the fact itself that a choice for a new job was actually made may easily influence the memory of the attitude at the moment of choice. Thus we have to confine ourselves to a simple question: do PhDs who work outside academia think more negatively about career prospects in academia than those who do work in academia? And is there a correlation between the perception of career prospects outside academia and the current sector of employment?

We do indeed observe that respondents outside academia were even more negative about the long-term career perspectives in academia than those who worked there. PhDs working in non-academic research were more positive about all four measured career prospects in their own sector than those in academia or outside research. PhDs working in academia were the least positive about the long-term career perspectives and the availability of permanent positions outside research. This shows that the influence of career prospects reported by the respondents themselves is not refuted by our measurement of their actual behavior, but is, in fact, confirmed.

5.4.4. Influence of other factors on actual job choice

Previously, we inferred that academia must have an autonomous force of attraction that compensates its relatively slim career prospects. This can be verified by means of the answers to questions about other factors that might have played a role in job choice. In the current section, we describe one that warrants special attention: job attributes that could have attracted PhDs towards their current job.

Naturally, there are variations in individuals' preferences for certain job attributes. Some individuals are more sensitive to factors relating to job content and intellectual development, whereas others are more sensitive to terms of employment. In the questionnaire we included nine items relating to job content and intellectual development, and nine relating to terms of employment. The respondents were asked to indicate which items played a role in the choice of their current job.

On the whole, factors relating to job content and intellectual development were more frequently ticked than factors relating to terms of employment (Table 3). Of the job content aspects, especially intellectual challenge (83%), degree of independence (70%), possibility to develop new skills (70%), creativeness (62%), level of responsibility (59%) and contribution to society (52%) played a role in job choice. Of the terms of employment, the opportunities for career advancement the job provides (47%), job security (33%) and salary (31%) were the most important factors.

The factors playing a role in job choice differed by sector of employment. Intellectual challenge, degree of independence and creativeness in a job, and personal and family-related circumstances were mentioned most often by PhDs working in academia (Table 3). Terms of employment such as salary, benefits, job security, job opportunities within the organization, permanent jobs within the organization, and the organization's HRM and career policy played a role more often for PhDs working in non-academic research. Contribution to society was also more often mentioned by non-academic researchers than others. Influence of career prospects on actual job choice: controlling for other factors.

Table 3. Job attributes that played a role in job choice by sector of employment

	Sector of employment				
Job attributes	Academia	Non-ac. res.	Outside res.	Total	p-value
Relating to intellectual development and job content					
Intellectual challenge	87	80	68	83	< 0.001
Degree of independence	76	65	57	70	< 0.001
Possibility to develop new skills	69	75	62	70	0.038
Creativeness	66	61	39	62	< 0.001
Level of responsibility	57	64	57	59	0.087
Contribution to society	49	58	55	52	0.022
Social status	20	21	23	21	0.605
Infringement on personal life	20	17	18	19	0.435
Workload	17	17	21	17	0.596
Relating to terms of employment					
Opportunities for career advancement	50	45	43	47	0.218
Job security	28	37	43	33	0.002
Salary	24	43	38	31	< 0.001
Travelling distance	26	29	37	28	0.084
Job opportunities within organization	19	32	24	23	< 0.001
Benefits	21	28	17	22	0.024
Availability of permanent jobs within the organization	21	25	21	22	0.301
Personal and family-related circumstances	25	17	17	22	0.010
Organization's HRM and career policy	8	18	11	11	< 0.001

N.B. Percentages may not add up to 100 due to rounding. P-values from Pearson's chi-squared test of independence between sector of employment and job attribute playing a role in job choice.

The findings presented above suggest that perceived career prospects in academia influence the choice of sector of employment, an effect that may be offset or rather amplified by other factors, such as desirable job attributes.

In every survey study there is a hazard that any association found between one factor and a certain observed outcome disappears when other independent variables are also taken into account. To assess whether this is the case for the relation between perception of career prospects and sector of employment, we used multinomial logit regression on sector of employment with the factors mentioned above, *and* other factors such as gender, nationality, etcetera, as independent variables. Thus we could determine whether perception of career prospects is associated with actual sector of employment independently from these other factors. The multinomial logit regression model reflects that a PhD can be employed in one of three sectors: academia, non-academic research, and outside research. We modeled the odds of being employed in non-academic research and of being employed outside research, both relative to being employed in academia.

The regression was performed first with only the perception of four dimensions of career prospects in academia as independent variables, next with only the control variables (so excluding the perception of career prospects), and finally with both perception of career prospects and control variables. All models were estimated using only respondents for whom no data are missing in the final model. It is worth noting that the "missingness" of data is not related to the outcome variable; the shares of PhDs in academia, non-academic research and outside research are comparable for all respondents for whom the sector of work is known (Table 1) and for those for whom no data are missing in the final model. We employed a stepwise backward elimination to include only those variables that explain a significant share of variance. Only including the perception of career prospects results in a pseudo-R^2 of 0.076; a model with only control variables in a pseudo-R^2 of 0.308 (Table 4). Including all variables gives a pseudo-R^2 of 0.351. These results indicate that perception of career prospects in academia is indeed an explanatory factor of sector of employment, though its explanatory power is not very strong.

The perception of career prospects in academia is independently associated with sector of employment: the more positive PhDs were about the long-term career perspectives in academia, the less likely they were to work in non-academic research (model 3; Table 4). This variable is not independently associated with working completely outside research, but the related variable of the availability of permanent positions is quite important here: the more positive PhDs were about the latter, the less likely they were to work outside research. Phrased differently: a lack of permanent positions drives people out of research, whereas those who are not deterred by this may move from academia to non-academic research if they think their perspectives of academic advancement are meager. Intriguingly, the more positive PhDs were about the quality of HRM and career policy in academia, the more likely they were to work outside research.

Job attributes also explain sector of employment. PhDs for whom intellectual challenge, degree of independence and creativeness played a role in job choice were less likely to work in non-academic research. Intellectual challenge and creativeness are also determinants of the odds to work outside research. Valuing the level of responsibility, contribution to society, salary and job opportunities within the organization are associated with working in non-academic research. PhDs who valued job security were more likely to work outside research than in academia. Finally, if personal and family-related circumstances played a role in job choice, the odds to be employed in academia increase. These findings are by and large in agreement with previous studies that found that PhDs working in academia have a greater "taste for science" than those not working in it (cf. Balsmeier & Pellens, 2014; Bloch et al., 2015; Roach & Sauermann, 2010). Also in agreement with the aforementioned studies we found that on the whole PhDs working outside academia found terms of employment more important than PhDs in academia. A slight difference to Roach and Sauermann's study (2010), however, is that we found that for PhDs working outside academia their contribution to society influenced their job choice more often than for PhDs in academia, whereas Roach and Sauermann found this item to more valued by PhD students who wished to work in academia than by those who wished to work in industry.

Job availability is another explanatory factor. The more positive about the number of jobs available in their preferred sector of work, the more likely PhDs were to work in non-academic research. Field of PhD also plays a role: engineering and technology PhDs were significantly more likely to be working in non-academic research than medical and health sciences, social sciences, and humanities PhDs. Interestingly, gender had no independent effect on sector of employment and was thus not included in the regression model. The same is true for years since PhD: the length of the period since the PhD was obtained does not explain the sector of employment for the respondents in our survey.

Table 4. Multinomial logistic regression on sector of employment

	Model 1		Model 2		Model 3	
	Non-ac. research B (S. E.)	Outside research B (S. E.)	Non-ac. research B (S. E.)	Outside research B (S. E.)	Non-ac. research B (S. E.)	Outside research B (S. E.)
Intercept	-0.65 (0.36)	-0.93 (0.57)	-4.00 (1.33)**	-4.10 (2.13)	-3.50 (1.38)	-3.95 (2.33)
Perception career prospects academia						
Long-term career perspectives	-0.43 (0.13)***	-0.50 (0.20)*	-	-	-0.38 (0.16)*	-0.43 (0.23)
Availability of permanent positions	0.13 (0.15)	-0.60 (0.27)*	-	-	-0.01 (0.18)	-0.90 (0.32)**
Period holding temporary positions	-0.07 (0.12)	0.14 (0.18)	-	-	-0.08 (0.14)	0.20 (0.21)
Quality of HRM/career policy	0.34 (0.13)*	0.42 (0.19)*	-	-	0.27 (0.16)	0.51 (0.21)*
Job attributes						
Intellectual challenge	-	-	-1.21 (0.37)***	-1.26 (0.46)**	-1.17 (0.38)**	-1.25 (0.50)*
Degree of independence	-	-	-0.92 (0.29)**	-0.24 (0.42)	-0.91 (0.30)**	-0.13 (0.45)
Creativeness	-	-	-0.48 (0.27)	-0.97 (0.38)*	-0.58 (0.28)*	-1.15 (0.41)**
Level of responsibility	-	-	0.64 (0.27)*	0.67 (0.41)	0.73 (0.28)**	0.90 (0.44)*
Contribution to society	-	-	0.60 (0.26)*	0.10 (0.35)	0.66 (0.26)*	0.03 (0.37)
Opportunities for career advancement	-	-	0.39 (0.25)	-0.61 (0.37)	0.39 (0.26)	-0.77 (0.40)
Job security	-	-	0.43 (0.27)	0.98 (0.38)**	0.40 (0.28)	1.02 (0.40)*
Salary	-	-	1.06 (0.27)***	0.63 (0.39)	0.97 (0.28)***	0.52(0.41)
Job opportunities within organization	-	-	0.85 (0.28)**	0.97 (0.39)*	0.84 (0.28)**	1.12 (0.42)**
Personal and family-related circumstances	-	-	-0.89 (0.31)**	-1.74 (0.59)**	-0.86 (0.31)	-1.91 (0.62)**
Other factors						
Job opportunities available	-	-	0.30 (0.11)**	-0.04 (0.16)	0.36 (0.12)**	0.15 (0.17)
Field of PhD (ref. engineering)						
Medical and health sciences	-	-	-0.88 (0.42)*	-0.31 (0.67)	-0.88 (0.42)*	-0.33 (0.71)
Natural sciences	-	-	-0.59 (0.42)	-0.11 (0.69)	-0.57 (0.43)	-0.29 (0.73)
Social sciences	-	-	-1.11 (0.48)*	-1.33 (0.80)	-1.01 (0.49)*	-1.23 (0.84)
Humanities	-	-	-1.68 (0.60)**	-0.71 (0.80)	-1.54 (0.62)*	-0.47 (0.84)
Personal characteristics						
Nationality high income OECD	-	-	0.73 (0.38)	2.48 (1.08)*	0.51 (0.41)	2.34 (1.17)*
Living with partner	-	-	0.65 (0.35)	-0.60 (0.42)	0.64 (0.36)	-0.85 (0.44)
Cox & Snell pseudo R^2	*0.076*		*0.308*		*0.351*	

Model 1: only incl. perception of career prospects, model 2: excl. perception of career prospects, model 3: all variables incl. perception of career prospects. *, **, and *** denote statistically significant difference of the independent variable at the 5, 1, and 0.1% levels, respectively. The variables of perception of career prospects in academia and of field of PhD were always included in the regression; the other variables were included following stepwise backward elimination (using p-value 0.10 of the F-test as threshold).

5.4.5. Main influencers of job choice: answers to open question

Phrasing of questions in a survey can easily influence the statistical results in unforeseen ways, especially in case of subjective phenomena, such as feelings and opinions. One way to prevent this is to ask open questions that give respondents the opportunity to provide background and to qualify their answers. We therefore included an open question in which respondents were asked what the main long-term career aspects were that had played a role in their career choices. Out of the 1,133 respondents, 754 (67%) answered the question. This unexpected bonus made it necessary to code the answers into a classification. Wherever possible, we coded them according to the variables delineated in our questionnaire. Still, a considerable number of other codes were needed and added iteratively. The main classes we delineated for our analysis are career prospects, short-term job availability, career goals, personal circumstances, and job attributes. We counted how often factors were mentioned by the respondents, and if they played a decisive factor in career choice. For example, quite a few people did mention slim long-term career perspectives in academia, but said other factors made them choose a job in academia anyway:

> *"Prospects for an academic career anywhere are not very high, let alone one in the Netherlands. My main motivations for pursuing this career path are the intellectual challenge and the freedom of picking research topics."*

In line with this, we made a distinction between factors playing a (decisive) role and those that did not.

The answers to the open question show that job attributes are the main factors that influenced the career choice of PhD graduates (Table 5). The most important job attribute is a fit with interest, previous experience or skills (e.g., *"I like research!"*, *"I want to be able to do research and teach in my field of expertise"*, *"I am a better doctor than an* [sic] *scientist"*). Following closely is the practical application of knowledge and contribution to society. Other major factors are the possibility to develop new skills and personal development in general, the degree of independence, job satisfaction in general (e.g., *"I like my job very much"*, *"For me, the most important are job satisfaction and the prospect of being able to continue doing this type of work for at least the near future (a few years)"*), and colleagues, teamwork, or work environment.

Table 5. Main influencers of career choices (%): answers to open-ended question*

	Played a role?				
	Yes	No		Yes	No
Career prospects			*Job attributes*		
Job security	19	1	Fit with interest, previous experience and/or skills	18	1
Degree to which job provided opportunities for career advancement	13	< 1	**Practical application and contribution to society**	18	-
Long-term career perspectives	7	5	**Personal development**	14	< 1
Job availability	2	< 1	**Degree of independence**	11	< 1
Required mobility	2	< 1	Job satisfaction in general	9	< 1
Quality of HRM/career policy	< 1	-	Colleagues/teamwork/work environment	8	< 1
Short-term job availability			**Intellectual challenge**	7	< 1
No alternative job available	2	-	Management position	5	< 1
Career goals			**Pecuniary rewards**	5	-
Career in academia	10	< 1	Variety in work	4	-
Career development	4	< 1	Pressure due to competition, obtaining grants and publishing	4	< 1
Career in non-academic research or outside research	3	< 1	**Creativeness**	3	-
Career in general	1	< 1	**Infringement on personal life**	3	-
Personal circumstances			**Level of responsibility**	3	-
Partner or family	4	-	International character	2	-
Location and travelling distance	1	-	Support by organization	1	< 1
Other personal circumstances	< 1	-	**Social status**	1	-
None			**Workload**	1	< 1
None	2	-	*Other*		
No answer	2	-	Other	3	-

* Based on 754 answers. Variables in bold were also measured through close-ended questions in the survey and presented in earlier paragraphs of this paper.

Although mentioned less often than job attributes, career prospects do play an important role in the career choices of many PhDs. Of the several aspects of career prospects, job security is the main one. For one in five PhDs it had played a decisive role in their career choice. Furthermore, for thirteen per cent of PhDs the degree to which the current job would provide opportunities for career advancement was decisive. Long-term career perspectives in general had played a decisive role for seven per cent of PhDs. Another five per cent acknowledged they played a role, though non-decisively (as in the answer mentioned above). Finally, a fit with career goals is a factor that plays a role in career choices. One in ten PhDs indicated their career choices had been guided by a wish to have a career in academia.

We also observed differences between sectors of employment. Job security played a key role in career choice more often for those outside academia than for those working in it. The same is true for pecuniary rewards, work environment (including colleagues and teamwork), and pressure due to competition, obtaining grants and publishing. Conversely, the degree of independence played a bigger role for PhDs in academia. An example of a respondent working in academia for whom independence was important:

> *"The possibility of gaining independence so that you can follow your own interests."*

Those working in non-academic research found the practical application of knowledge and contribution to society more important that PhDs working in other sectors. For example, one respondent working in non-academic research said:

> *"Moreover the importance of first and last authorships does not promote collaboration. I discovered that teamwork and data quality are valued much more in the industry than academia which made me decide to leave academia."*

PhD graduates working outside research indicate that their family had played a role in their job choice more often than PhDs in other sectors. Almost half of those also mention job security, e.g.,:

> *"For me the most important thing has always been to have a job that interests me and in which I feel I am contributing to society. Since I have a family income stability is getting more and more important."*

Finally, and unsurprisingly, career goals are in agreement with the current sector of employment. PhDs in academia much more often said that their career choices had been guided by a wish to work in academia. Likewise, PhDs outside academia more often had the goal of a career outside academia, in non-academic research or outside research.

5.5. Conclusions and policy implications

Career prospects of recent PhDs is a much debated topic, but few studies have systematically addressed how PhD graduates view these prospects. Our present study addresses this question, through a survey of recent PhDs graduates from five Dutch universities. The central conclusion emerging from the survey results reported in preceding sections is that PhD graduates have a negative view of career prospects in academia and that this negative view influences their job choice. What does this mean for the adequacy of the career system at universities and other academic institutions?

Clearly, the negative view of career prospects in academia puts this sector at a comparative *disadvantage* with competing sectors of employment. All other things being equal, the PhDs' preference would be to leave academic research for other sectors. However, all other things are not equal. Our results also show that, first and foremost, a job must be interesting to PhDs. When choosing a job, what guides them most is how fulfilling the job is: how intellectually challenging, what is the degree of independence, what are the possibilities for personal development, and which contribution it can make to society. For PhDs who work in academia, intellectual challenge and degree of independence played a role in job choice more often than for PhDs working elsewhere. Other studies have called a preference for such attributes a "taste for science", which is more easily satisfied in academia than elsewhere (e.g., Balsmeier & Pellens, 2014; Bloch et al., 2015; Roach & Sauermann, 2010). This factor gives academia a comparative *advantage* to other sectors. The interplay of this comparative advantage with the career disadvantage determines how the latter influences the comparative labor market position of academia.

In this respect a major question is, of course, which factor is the strongest: the negative influence of the career system (a push factor) or the positive influence (a pull factor) of the intellectual aspects of jobs in academia. Our survey cannot determine this, but since there is no shortage of PhDs willing to work in academia, it is clear that *quantitatively* universities can afford the comparative disadvantage at which the present career system places them.

Qualitatively, however, the situation is quite different. The interplay of the push and pull factors must have influence on the composition of the academic work force. First, there is no guarantee that there is a perfect correlation between the importance that PhDs attach to a job's intellectual aspects and their research capabilities. Since it is well known that the distribution of research capabilities is quite skewed (cf. De Solla Price, 1963) any push factor that is not precisely compensated at the individual level by a pull factor, must cause some of the best researchers to leave academia. If the share of the best researchers that is pushed out is equal to that of "average" researchers, the skewed talent distribution implies that there is a substantial loss of academic output that would not occur if a larger share of the best researchers could be retained. Although these researchers could have considerable societal impact through their work outside academia, from the perspective of universities it is a loss if they work elsewhere.

In our survey we have no knowledge about research capabilities and therefore cannot determine whether some of the best researchers are indeed driven out of academic research by the career prospects. However, an aspect we do have information on, is the attitude with respect to societal impact (translating research results into societally relevant applications, science communication, and so on). We found that for PhDs outside academia, contribution to society played a role in job choice more often than for PhDs in academia. Furthermore, PhDs who attach such importance to their contribution to society also attach greater importance to job security. In the light of the increasing focus on societal impact at universities (de Jong, Smit, & van Drooge, 2016), this is an important finding. It means that the present career systems may well be selective against PhDs with an affinity for impacting society.

In summary, recent PhD graduates' negative view of the academic career opportunities does not cause a shortage of academic researchers. However, it quite possibly drives out some of the most capable researchers and selects against academic researchers with an affinity for making an impact on society.

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CHAPTER 6

Temporary contracts: effect on job satisfaction and personal lives of recent PhD graduates

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Abstract

In this study, we assess the effects of temporary employment on job satisfaction and the personal lives of recent PhD graduates. Temporary employment is becoming increasingly prevalent in many sectors, but has been relatively common in academia, especially for early-career scientists. Labor market theory shows temporary employment to have a conspicuous negative influence on the job satisfaction and well-being of employees, but also identifies groups that may be exempt from these negative influences, such as the highly educated. Here, we study the effect of temporary employment on the highest educated group in the labor force, PhD graduates. We present findings of a survey of 1,133 respondents who obtained their PhD from one of five Dutch universities between 2008 and 2012. Compared to PhDs employed on a permanent contract, PhDs on a temporary contract are less satisfied with their terms of employment, especially if they have no prospect of permanence. Temporary contracts with no prospect of permanence also decrease satisfaction with job content. Conversely, self-employment increases satisfaction with job content. Educational level required for the job also influences job satisfaction to a large degree: working below PhD level negatively affects job satisfaction. Finally, the type of contract affects different aspects of the personal lives of PhDs, such as the ability to obtain a mortgage, the stability of family life, and the possibility to start a family. In conclusion, we show that the highest educated, i.e., PhD graduates are not exempt from the negative influences of temporary employment.

6.1. Introduction

Temporary (or fixed-term) employment is becoming a reality for an increasing share of academic researchers. The increase in temporary contracts for academics is especially pronounced for early career researchers and can be observed in many countries, such as the United States (Schuster & Finkelstein, 2006, p. 194), Germany (Waaijer, 2015) and the Netherlands (Association of Dutch Universities, 2016). However, this shift from permanent to temporary employment is not confined to academia, but applies to all employment sectors. For example, in the Netherlands about half of all recent university graduates are employed on a temporary contract (Bertrand-Cloodt, Cörvers, Kriechel, & van Thor, 2012; Statistics Netherlands, 2014). Still, in academia temporary employment is even more prevalent than in other sectors, which is easily exemplified by looking at the employment of PhD graduates who have just received their PhD: two thirds of PhD graduates working outside academia have a permanent job, compared to only one third for those working in academia (Sonneveld, Yerkes, & van de Schoot, 2010).
The prevalence of temporary employment in academia compared to other sectors raises the question what its effects are on early career researchers. In this study, we study:

1. What is the effect of temporary employment on the job satisfaction of recent PhD graduates?
2. What is the effect of type of employment on the personal life of recent PhDs?

Recent PhDs make for an interesting group to study this effect as we expect a relatively large dichotomization in type of employment by sector. In addition, the fact that the group consists of both permanently and temporarily employed persons makes it possible to estimate the effect of temporary employment using a "control" group of permanently employed persons. This is not possible using a group of postdoctoral researchers, for example, as most of these will be employed on a temporary contract. Furthermore, PhDs are an interesting group because they are the highest educated persons in the labor force. Whereas the effects of temporary employment on the labor force as a whole have been relatively well-studied, this is less the case for the highly educated, and not at all for PhDs.

The remainder of the paper is structured as follows. In a review of the literature, we will first provide several theories on the effects of temporary employment, coming from labor market, organization and career literature. Special attention will be given to the national context of the study. Furthermore, we will discuss literature on job satisfaction, focusing on previous studies on job satisfaction among PhDs and factors that influence their job satisfaction. In the methodology section we will describe how the survey has been conducted and which variables were measured. The results and discussion section starts by providing data on the prevalence of different types of temporary employment among the respondents. Then, we will show a comparison of several aspects of job satisfaction by type of employment. As a next step, we determine the effect of temporary employment on job satisfaction while controlling for other factors that may influence it. Finally, we show how type of employment affects the personal lives of recent PhD graduates. In our conclusions section we put our results into the context of the labor market and career literature, and describe the policy implications of our study.

6.2. Literature review

6.2.1. Temporary employment

In their human resource management, organizations must decide on a strategy regarding the contractual arrangements and thereby the employment relationships with their employees. Most organizations have a core workforce of employees on permanent contracts, supplemented by a flexible supply of temporary workers (Aldrich & Ruef, 2006, p. 97). Having a small core workforce offers the flexibility to adapt to changes in the economic environment, e.g., by reducing the workforce when demand decreases or by adapting the workforce to meet changed skill requirements, without the costs of redundancy pay (Bertrand-Cloodt et al., 2012; Cörvers, Euwals, & de Grip, 2012). At the same time, temporary employees are less likely to be committed to the organization and the knowledge temporary employees obtained is lost when they find employment elsewhere (Aldrich & Ruef, 2006, p. 97). Having a larger core workforce counteracts these issues. In conclusion, there is a tradeoff between the long term (commitment and obtained knowledge) and the short term (flexibility) in contractual arrangement strategies.

In case of universities and public research organizations, these considerations do not apply at the institutional level: their budgets are not heavily determined by market forces and are fairly stable. This is true even in cases where a considerable share of funding is obtained from competitive funding: the sources of competitive funding are themselves fairly stable, and the shares of individual research organizations competing for competitive funding sources are also relatively stable. However, at the level of departments and institutes within the organization, funding levels are more unstable and there the organizational and economic arguments mentioned above might apply. In addition, the acting management of the organizations may apply these considerations to their employees, in order to avoid risks of conflicts within the organization. This could be a reason for the large share of temporary employees modern research organizations, but this mechanism has not been studied in great detail. From work by one of us it appears that this large share has developed mainly as a consequence of the end of the large (budgetary) expansion of the higher education system as a whole (Waaijer, 2015).

For workers, too, temporary employment may have two faces. On the one hand, according to dual labor market theory temporary jobs may be considered as low quality or even “bad” jobs with low pay and no access to benefits (Kalleberg, Reskin, & Hudson, 2000), from which it is difficult to find a high quality job due to labor market segmentation (e.g., Reich, Gordon, & Edwards, 1973). These bad jobs do not only have poorer terms of employment than permanent jobs, but also have poorer job content, e.g., featuring more monotonous tasks, less opportunity to learn new things and less often being sufficiently demanding (Letourneux, 1998). Still, temporary jobs may be preferable to unemployment and can provide a “stepping stone” to a permanent job, especially for university graduates (Bertrand-Cloodt et al., 2012).

On the other hand, another body of literature on careers postulates temporary employment to enable “boundaryless careers”, in which workers do not work in one organization throughout their working life, but rather change employers more often and develop themselves as they wish (Arthur & Rousseau, 1996). Following this theory, Marler, Woodard Barringer and Milkovich (2002) distinguish “boundaryless” and “traditional” temporary employees and find that the boundaryless employees, who prefer temporary jobs, have a higher skill level and experience. Combining both the “stepping stone” and “boundaryless” theories of temporary employment, temporary jobs may not be “bad” jobs for PhD graduates, who are the highest educated group on the labor market.

A reason for this may lie in the psychological contracts formed between employers and employees. A psychological contract is defined as “individual beliefs, shaped by the organization, regarding terms of an exchange between individuals and their organization” (Rousseau, 1995, p. 9). If the individual believes the terms of exchange have been breached, the psychological contract is violated. This leads to increased turnover and a decrease in trust and satisfaction in an employment context (Robinson & Rousseau, 1994). Using the stepping stone analogy, young, highly educated employees on a temporary contract could experience a balanced exchange between themselves and the employer: employees offer (temporary) labor to the employer, and in turn gain job experience, which they can use in another job. In this case, temporary employment does not necessarily lead to decreased job satisfaction. Indeed, a recent study by Lam and de Campos (2015) found that young scientists involved in so-called collaborative research experienced a balanced psychological contract with their professor or employer and remained invested in their current job, despite the fact that some of them seemed trapped in perennial temporary employment. On the other hand, Thunnissen (2015) described the human resources policy at Dutch universities as an unbalanced situation, in which the long spells of temporary employment for scientists led to dissatisfaction. In this study, we can test whether temporary employment affects recent PhDs.

6.2.2. The national context: temporary employment in the Netherlands

As already indicated in our introduction, the past years have seen a large increase in temporary employment in the Netherlands (Bierings, Kooiman, & de Vries, 2015). There have been increases in the share of employees with a temporary contract, in the share of self-employed persons without employees (*zelfstandige zonder personeel* or *zzp'er*) and in the share of self-employed persons with employees. By 2013, the Netherlands ranked third among the EU-15 countries regarding the share of employees with a temporary contract, after Spain and Portugal (Kösters & Smits, 2015). An explanation for a large share of temporary employees is high levels of legal protection against dismissal – in countries where the legal protection against individual dismissal is high, organizations achieve labor flexibility by hiring employees on a temporary contract (Kösters & Smits, 2015). When the difference in legal protection of permanent and temporary employees is smaller, the share of temporary employees is often smaller.

In response to the increasing shares of temporary employees, the Netherlands adopted a new law regarding temporary employment, which became effective on 1 July 2015 (Government of the Netherlands, 2015). In this law, dismissals were simplified by reducing the number of possible legal procedures. At the same time, employees gained the right to compensation if the employer fired them or if they had been employed for over two years. In addition, the maximum number of years on a temporary contract was reduced from three to two (with an exception for universities, for whom this period is four years). After this period, employees should be employed on a permanent contract. In addition, employees can only be employed on three temporary contracts (both before and after the change in the law). Before the changes in the law, multiple three-year periods of employment could follow each other if there was a three-month break in-between the periods. This break has now been extended to six months. Together, these measures were supposed to make the difference between permanent and temporary contracts smaller and incentivize employers to hire more employees on a permanent contract.

However, at the time of writing, it is unclear whether the law has actually been effective. The number of permanent contracts in the third and fourth quarter of 2015 actually decreased compared to the number in the respective quarters in 2014 (Statistics Netherlands, 2016a). In addition, there are signals that employers (especially small organizations) have become more hesitant to employ workers on a permanent contract due to the compensation at dismissal (de Koning, 2016). This is mainly due to legal regulations concerning long-term illness – if employees get a long-term illness, they cannot be fired for two years and employers have to pay for their sick leave during this period. After these two years, employers can file for dismissal, but now also have to pay compensation.

Similarly, the increase in the number of self-employed persons has led to discussion and changes of laws. By some, this increase is being hailed as a sign of entrepreneurship, by others as hidden form of unemployment for those who cannot find a job (Hofs, 2016; Witteman & de Haan, 2016). In their newspaper article, Witteman and De Haan conclude that both are true: disproportionally many self-employed persons are either at the top or at the bottom of the income distribution. In financial and commercial services and in health care, income is the highest. In the food service industry and in the culture, sport and recreation sector income is lowest. On average, the income of self-employed persons is lower than that of salaried workers (Statistics Netherlands, 2016b). There is one exception: physicians are the only group for whom the income is significantly higher as a self-employed person than as a salaried worker.

As a large share of PhD graduates works in academia shortly after their PhD, temporary employment in academia merits special attention. As already stated in the introduction, the share of temporary employees at Dutch universities has increased over the past fifteen years, the share of temporary academic employees having increased from 43% in 1999 to 62% in 2014 (Association of Dutch Universities, 2016). Particularly within the categories of other scientific staff (a category mainly made up of postdoctoral researchers) and assistant professors (Dutch: *universitair docenten*), positions have increasingly become temporary. With these trends, obtaining a permanent position at a Dutch university has become more difficult over the years. Still, opportunities for a permanent position are still larger than in, for example, Germany, where researchers are appointed as research affiliates on a temporary contract for long periods of time (Kreckel, Burkhardt, Lenhardt, Pasternack, & Stock, 2008).

A large majority of recent PhDs from Dutch universities work in the Netherlands. As such, the job market that they operate in, is one of increasing flexibility. An earlier study by one of us among postdoctoral researchers in the Netherlands has shown that the temporary nature of these positions affects job satisfaction (van der Weijden, Teelken, de Boer, & Drost, 2016), and so has a study among postdocs in Germany, Austria and Great Britain (Höge, Brucculeri, & Iwanova, 2012). Still, no studies have determined the effect of temporary employment on the job satisfaction of PhDs by using a control group: PhDs with a permanent position – which is what this study sets out to do.

6.2.3. Job satisfaction

Job satisfaction has been defined by Locke (1969) as "the pleasurable emotional state resulting from the appraisal of one's job as achieving or facilitating the achievement of one's job values". Thus, job satisfaction is the result of the relation between a person's values and the extent to which the job's attributes can facilitate the achievement of these values. Many different factors can affect job satisfaction. An important one is the level of the job: a skill mismatch negatively influences job satisfaction (Allen & van der Velden, 2001; Mavromaras, McGuinness, O'Leary, Sloane, & Wei, 2010). The type of employment also plays a role: in a meta-analysis Wilkin (2013) showed that non-permanent employment decreases job satisfaction. The type of non-permanent employment matters: self-employed persons are as satisfied as permanent employees, whereas agency workers and direct-hires (i.e., persons hired on a temporary contract directly by the company) are less satisfied.

Job satisfaction among (recent) PhD graduates has been assessed for several countries and regions and is generally quite high (e.g., Bender & Heywood (2006), and Moguérou (2002) for the U.S., Di Paolo (2016) for Catalonia; Kifle & Desta (2012) for Australia). Many of these studies (e.g., Bender & Heywood, 2006; Di Paolo, 2016; Moguérou, 2002) found that PhDs working outside of academia are overall less satisfied with their job than those working in academia, although Di Paolo (2016) found that PhDs in non-academic jobs are more satisfied with pecuniary rewards. Skill matches play a large role among PhDs: a skill mismatch is associated with lower job satisfaction (Bender & Heywood, 2009).

In the general labor force, multiple other factors have been shown to affect job satisfaction, and were therefore also measured in our survey (for a complete list of variables, see the methodology section). Part-time employment may have an effect, but this effect is ambiguous, with some studies finding a positive effect, some a negative one, and some none (Conway & Briner, 2002). Time in job also affects job satisfaction: directly after finding a new job people are more satisfied with their job (the "honeymoon effect"), but later they are less satisfied (the "hangover effect", e.g., Boswell, Shipp, Payne, & Culbertson, 2009; Lawler, Kuleck, Rhode, & Sorensen, 1975; Vroom & Deci, 1971). Furthermore, having a mentor has been shown to contribute to job satisfaction, through an increase in self-confidence (e.g., Nick et al., 2012).

In addition, a number of personal characteristics have been found to influence job satisfaction, both in the general labor force and more specifically among academics or PhD graduates. For example, satisfaction varies by field of PhD (e.g., Moguérou, 2002; Sabharwal & Corley, 2009). Females tend to be more satisfied with their job than males, not because their jobs are better, but because the expectations they have of their jobs are lower (Clark, 1997). However, the same paper finds that this gender difference, with women being more satisfied, disappears for the highly educated, and for persons in professional and managerial positions. Indeed, studies on the job satisfaction of PhD graduates have found female PhDs to actually be *less* satisfied (Bender & Heywood, 2006; Moguérou, 2002). Nationality also matters: US-born science and engineering faculty were found to be more satisfied with their job than foreign-born faculty (Sabharwal, 2011).

6.3. Methodology

6.3.1. Sample and survey methodology

Our survey was developed to gain more knowledge on the labor market position of recent PhD graduates from Dutch universities. Topics included job choice, perception of career prospects, use of skills developed during PhD, mentoring experiences, and the value of the PhD degree. A detailed description of the sample and survey methodology can be found in our working paper on the development of the survey questionnaire (Waaijer, Belder, van Bochove, Sonneveld, & van der Weijden, 2015). The survey sample consisted of 2,193 PhD graduates. Of these, 1,023 persons obtained a PhD between April 2008 and March 2009 from Utrecht University (a large, broad research university), Delft University of Technology (engineering and technology), Wageningen University (historically focused on agriculture but now broadening its scope to life sciences and environmental research), and Erasmus University Rotterdam (focused on medicine and social sciences, especially economics, law and management). This group has been approached before in a previous survey (Sonneveld et al., 2010). Another 1,170 PhDs in the sample obtained a PhD between January 2008 and May 2012 from Leiden University, which performs research in all major areas except engineering and economics. Universities in the Netherlands differ in terms of scope, but are (almost) all deemed to be of good quality and reputation, without very high or low outliers (Government of the Netherlands, 2014). The universities that the respondents obtained their PhDs from are no exception.

A survey invitation was sent to the 2,193 PhDs in the survey sample, as well as up to three reminders if they had yet to fill in the survey. The survey was open for 91 days. A total of 1,133 respondents started the survey, a 51.7% (partial) response rate. Of the complete sample, 43.8% progressed to the final question (960 respondents).

6.3.2. Variables

The variables measured were type of employment contract, several aspects of job satisfaction, other employment characteristics (sector of employment, level of the job, part-time employment, time in job, and presence of a mentor), PhD characteristics (field of PhD, time since PhD), and personal characteristics.

6.3.2.1. Employment status

One of our main variables was employment status by type of employment contract. Workers may have a permanent job contract, a temporary contract, or be self-employed. However, temporary contracts may vary in their flexibility: workers might have the prospect of obtaining a permanent position when performing their job well, or they might not. Therefore, we made a distinction between three types of temporary contracts: permanent but in a probation period, temporary with tenure track, and temporary without the prospect of a permanence. This resulted in five employment types: permanent contract, probation period of a permanent contract, tenure track contract, temporary contract without prospect of permanence, and self-employment. Self-employed persons are those doing paid work, but who are not employed by an employer.

6.3.2.2. Job satisfaction

A total of eighteen aspects of job satisfaction were measured, regarding job content, terms of employment, and work-life balance. The questions for several variables were drawn from the Careers of Doctorate Holders Survey model questionnaire (Auriol, Felix, & Schaaper, 2010). Respondents were asked to rate the variables on a five-point Likert scale ranging from “very satisfied” to “very dissatisfied”.

6.3.2.3. Other employment characteristics

In our study we distinguished three sectors of employment: academic R&D, non-academic R&D, and non-R&D. The grouping of the respondents into these categories was based on two variables: involvement in R&D and type of employer. The Organisation for Economic Co-operation and Development (OECD) distinguishes three types of R&D: basic research, applied research, and experimental development (OECD, 2002). PhDs not involved in any of the three types of R&D in their main job were classified as working in non-R&D (further dubbed outside research). PhDs in academic R&D (further dubbed academia) are PhDs involved in R&D and employed at a university, university of applied sciences or college, academic hospital, or research institute. Non-academic R&D jobs (further dubbed non-academic research) are held by PhDs involved in any type of R&D and working at another type of institution (e.g., at a private business, government institution, non-academic hospital).

Other measured job characteristics were the level of the job, full-time or part-time employment, and the time in job. We measured two aspects of job level: whether respondents had a supervisory role, and the education level normally required for their job. The four education levels were bachelor or lower, master, PhD, and professional degree (e.g., medical degree). Although some studies do not find a negative effect of overeducation on job satisfaction (e.g., García-Espejo, 2006), other studies do (Hersch, 1991). This effect has been found to be mediated by a skill mismatch rather than an educational mismatch (Allen & van der Velden, 2001; Mavromaras et al., 2010). However, as educational level is a more straightforward measure we chose this variable.

In addition, to measure experienced support in their current job, we asked the respondents whether they have a mentor. A mentor is “a more skilled or more experienced person who serves as a role model, teaches, sponsors, encourages for the purpose of promoting the latter's professional and/or personal development" (Anderson & Shannon, 1988). As the definition of a mentor may not be self-explanatory, this definition was given to the respondents in the questionnaire.

6.3.2.4. PhD characteristics

Respondents were asked to indicate in which field they did their PhD. The fields were medical and health sciences, natural sciences (including agricultural sciences), social sciences, humanities, and engineering and technology. Fields were chosen in such a way that different disciplinary contexts could be taken into account while still allowing for sufficient power in our statistical analyses. Furthermore, we measured the number of years since PhD.

6.3.2.5. Personal characteristics

Measured personal characteristics were gender, nationality, relationship status, and having young children. All variables were measured as dummy variables: gender as male or female, nationality as having the Dutch nationality or not, relationship status as living with a partner or not, and having young children as having children below the age of six or not.

6.4. Results and discussion

6.4.1. Employment status

To provide background information to the extent of temporary employment among recent PhDs, we assessed the respondents' employment status. Half of the respondents (with a job at the time of the survey) have a permanent contract (Table S1 in appendix 5). Just over a third have a temporary contract without the prospect of obtaining permanence, seven per cent are self-employed, six per cent have a tenure track contract, and three per cent are in the probation period of a permanent contract. Types of employment contract differ by sector of work: the share of permanent contracts is highest in non-academic research, lowest in academia, and intermediate outside research. The share of PhDs on a tenure track contract is highest for academic PhDs. Finally, nineteen per cent of PhDs in non-academic research and thirteen outside research are self-employed. The share of PhDs on permanent contracts is higher for those when PhD was obtained longer ago: 40 per cent after one to three years and 55 per cent after four to five years. The difference is particularly pronounced for those in academia.[1]

[1] Only for PhDs outside research the share of PhDs on temporary contracts without prospect of permanence does not go down; this is likely to be caused by the fact that many of them are residents (medical specialists in training, e.g., to train as a neurologist), which are temporary positions that can last up to six years for some medical specialisms.

6.4.2. Job satisfaction: simple comparison of job satisfaction aspects between employment types

Now, we turn to the actual impact of temporary employment on job satisfaction. PhDs were asked to rate a total of eighteen aspects of job content, terms of employment, and work-life balance. In general, they are very satisfied with many aspects. PhDs are generally (very) satisfied with the content of their job, but less satisfied with the terms of employment and some aspects of work-life balance.

We compared different aspects of job satisfaction between the different employment statuses. The answers to the job satisfaction questions were not normally distributed over the answer categories, so we used the Mann-Whitney U test to determine whether there were statistically significant differences between the groups. We compared the satisfaction of PhDs on a permanent contract to that of PhDs with other employment statuses. This revealed that PhDs on temporary contracts are, unsurprisingly, less satisfied with job security than those on a permanent contracts, especially if they have no prospect of permanence (Fig. 1). The PhDs on a temporary contract without the prospect of permanence are also less satisfied with several other aspects, i.e., their contribution to society, salary, personal and family-related circumstances, social status, benefits, infringement of job on personal life, availability of permanent jobs within the organization, the organization's career policy and HRM, and job opportunities within the organization. The one aspect they are more satisfied with than those on a permanent contract, is the intellectual challenge of their job. PhDs on a tenure track contract and self-employed PhDs are more satisfied with this aspect as well. Furthermore, self-employed PhDs are more satisfied with their degree of independence, creativeness, level of responsibility, and social status.

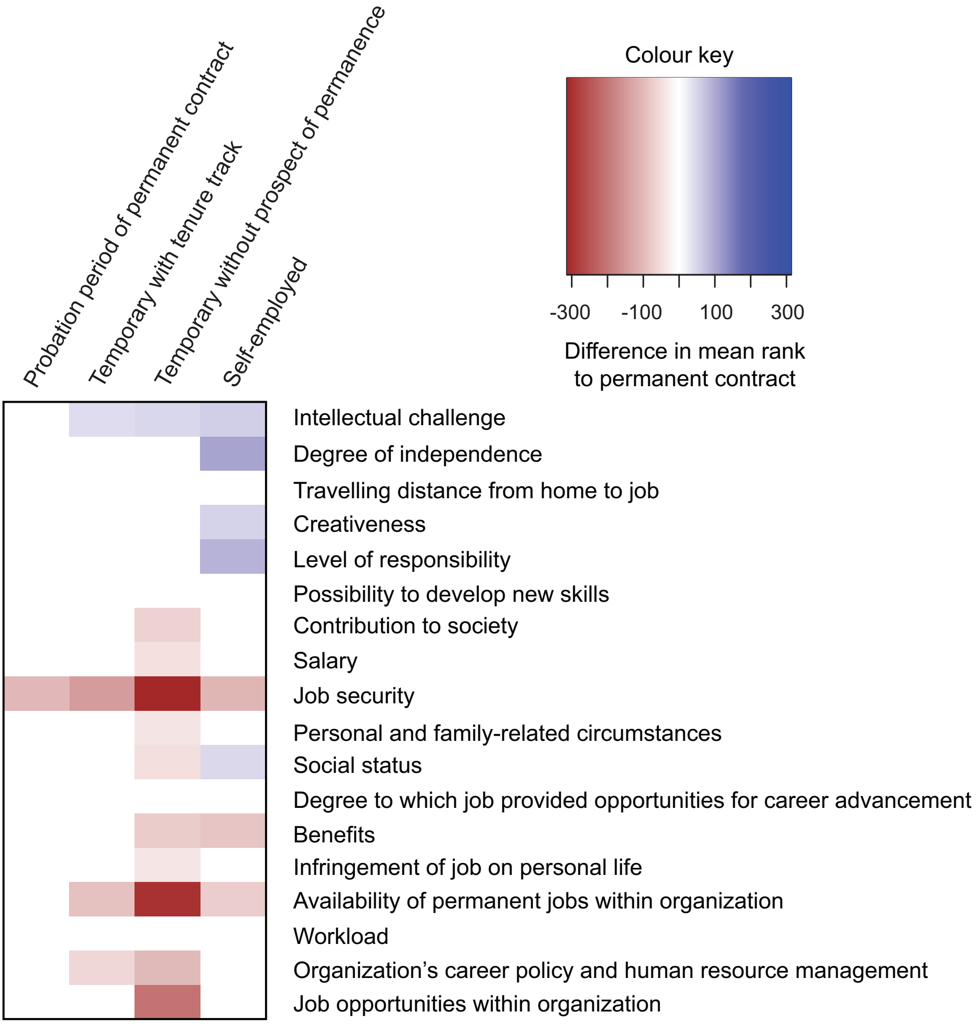

Figure 1. Job satisfaction by employment status. Depicted in the heatmap are the statistically significant differences in mean rank between different types of non-permanent employment and a permanent contract in matrix format (Mann-Whitney U test, $p < 0.05$). In brown are the aspects that PhDs on a temporary contract (or being self-employed) are less satisfied with than those on a permanent contract; in blue the ones that they are more satisfied with. The brighter the color, the larger the difference. Heatmap generated using the R package `ggplot2`

6.4.3. Job satisfaction: effect of employment status controlling for other variables

Thus it appears that temporary contracts have a considerable (adverse) effect on job satisfaction, especially when it comes to terms of employment. However, it remains to be seen if this effect also exists if other factors affecting job satisfaction are taken into account.

6.4.3.1. Combination of job satisfaction variables into three scales

In the questionnaire, job satisfaction as such is not a variable: what is measured is the satisfaction with many separate aspects of the job. These have to be combined in order to obtain a job satisfaction variable. We did not combine all aspects into a single variable, but instead defined three job satisfaction scales: job content, terms of employment, and work-life balance based on exploratory factor analysis using principal component extraction and promax rotation (Table S2). After factor analysis, the reliability of the three scales was determined. For the scale of satisfaction with work-life balance, the Cronbach's α score was lower than 0.7. Therefore, two variables, satisfaction with travelling distance and with personal circumstances, were excluded. After removal of these items the Cronbach's α scores were at least 0.77 for all three scales. For the satisfaction with work-life balance scale the average score on the two items was computed. For the scales on satisfaction with job content and with terms of employment, the average score was computed if four or more items out of the seven scale items were answered.

6.4.3.2. Satisfaction with job content

We ran a linear regression of job satisfaction on both employment status and other characteristics. These characteristics were other employment, PhD and personal characteristics. Table 1 shows the results of the regression of the three job satisfaction scales on employment status and the other characteristics. In our analyses, we tested for interaction between gender and having children, but no interaction was found and thus not included in the model.

Self-employment increases the satisfaction with job content, whereas temporary contracts without prospect of permanence decrease it. Thus, employment status influences satisfaction with job content. Like Wilkin (2013), we show that the type of "non-permanence" matters, with self-employment not decreasing satisfaction with job content (rather *increasing* it), whereas temporary contracts without prospect of permanence do decrease it (albeit to a small extent). Thus, our results indicate that for PhDs, self-employment is an attractive option, as it gives them more satisfaction with degree of independence, level of responsibility, intellectual challenge, creativeness and social status (see Fig. 1). Self-employed PhDs appear to be part of the group of self-employed persons in the Netherlands who mainly reap the benefits of self-employment, instead of the group who is self-employed because they cannot find employment at an employer (Witteman & de Haan, 2016). From these results, a policy implication could be that PhDs should be encouraged to set up their own businesses. Self-employed PhDs do, however, differ from other PhDs in one aspect: age. At the year of PhD, they were on average 41 years old, whereas those now employed on a permanent contract were on average 35 years, and those on temporary contracts between 31 and 32. Therefore, it may be their work experience that makes self-employed successful and thereby satisfied with their jobs, rather than (just) the fact they are self-employed.

Table 1. Effects of employment, PhD and personal characteristics on three scales of job satisfaction (linear regression)

	Job content		Terms of employment		Work-life balance	
	B (S. E.)	p-value	B (S. E.)	p-value	B (S. E.)	p-value
Intercept	3.76 (0.11)	< 0.001***	3.43 (0.12)	< 0.001***	3.33 (0.17)	< 0.001***
Employment status (ref. is permanent contract)						
Probation period of permanent contract	-0.18 (0.13)	0.181	-0.13 (0.14)	0.347	-0.05 (0.20)	0.807
Temporary contract with tenure track	-0.04 (0.10)	0.689	-0.33 (0.10)	0.001**	-0.33 (0.15)	0.025*
Temporary contract without prospect of permanence	-0.12 (0.06)	0.031*	-0.71 (0.06)	< 0.001***	0.04 (0.09)	0.637
Self-employed	0.48 (0.10)	< 0.001***	-0.11 (0.11)	0.310	0.03 (0.15)	0.825
Other employment characteristics						
Supervisory role in job	0.14 (0.05)	0.003**	0.16 (0.05)	0.001**	-0.03 (0.07)	0.676
Educational level required for job (ref. is PhD)						
Bachelor or lower	-0.38 (0.15)	0.014*	-0.64 (0.16)	< 0.001***	-0.13 (0.23)	0.565
Master	-0.20 (0.06)	0.002**	0.06 (0.07)	0.376	0.07 (0.10)	0.446
Professional degree (e.g., M. D.)	-0.03 (0.08)	0.711	0.10 (0.08)	0.218	-0.45 (0.12)	< 0.001***
Sector of work (ref. is academia)						
Non-academic research	-0.08 (0.06)	0.176	0.21 (0.06)	0.001**	0.09 (0.09)	0.295
Outside research	-0.11 (0.08)	0.180	0.19 (0.08)	0.025*	0.09 (0.12)	0.441
Having mentor in current job	0.19 (0.05)	< 0.001***	0.11 (0.05)	0.028*	0.08 (0.07)	0.264
Years in job	0.00 (0.01)	0.636	-0.02 (0.01)	0.002**	-0.02 (0.01)	0.003**
PhD characteristics						
Field of PhD (ref. is engineering and technology)						
Medical and health sciences	-0.08 (0.09)	0.369	-0.08 (0.09)	0.349	-0.05 (0.13)	0.696
Natural sciences	0.06 (0.08)	0.476	0.14 (0.09)	0.111	-0.06 (0.12)	0.620
Social sciences	-0.10 (0.09)	0.285	-0.02 (0.10)	0.872	-0.08 (0.14)	0.580
Humanities	0.02 (0.09)	0.818	-0.16 (0.10)	0.104	-0.30 (0.14)	0.033*
Personal characteristics						
Dutch	0.07 (0.06)	0.212	-0.09 (0.06)	0.152	-0.06 (0.09)	0.508
Female	-0.01 (0.05)	0.821	-0.01 (0.05)	0.766	-0.15 (0.07)	0.027*
Living with partner	-0.02 (0.06)	0.738	-0.05 (0.06)	0.459	0.08 (0.09)	0.373
Children below 6	0.11 (0.05)	0.021*	0.00 (0.05)	0.992	0.08 (0.07)	0.295

*, **, and *** denote statistically significant difference of the independent variable at the 5, 1, and 0.1% levels, respectively.

6

The level of the job matters, too: having a supervisory role has a positive effect on job satisfaction, whereas having a job below PhD level has a negative influence. This negative effect of working below PhD level on the satisfaction with job content is in accordance with Bender and Heywood's study (2009), which found that skill mismatches are associated with lower job satisfaction among U.S. PhD graduates. The mismatch between educational attainment of PhDs and job level is not a marginal phenomenon, as more than twenty per cent of PhDs indicate they have a job at master's level, and another two per cent a job at bachelor level or lower. These shares are higher for PhDs outside academia than in academia (Table 2).

Table 2. Educational level required for job by sector of employment

Educational level	Ac. R&D	Non-ac. R&D	Non-R&D	Total
		%		
Bachelor or lower	0	4	7	2
Master	7	35	53	21
PhD	82	48	24	65
Professional degree (e.g., M. D.)	11	13	17	12

The finding that skill mismatches are a strong negative influencer of satisfaction and that they are more prevalent outside academia has an important implication. Previous studies have found that PhDs working outside academia are less satisfied with their job than those working in academia (e.g., Bender & Heywood, 2006; Moguérou, 2002). However, we do not find such an effect of employment sector when type of employment and required educational level are controlled for. This is a consequence of the relation between sector of employment and required educational level. As such, it is the job's required educational level that affects satisfaction with job content, rather than sector of employment itself.

Our results indicate that outside academia, PhDs have more trouble finding jobs that are intellectually challenging and that offer autonomy, values they find very important in their job choice (e.g., Bloch, Krogh Graversen, & Skovgaard Pedersen, 2015; Roach & Sauermann, 2010; Waaijer, 2016). The current study shows that not only are jobs outside academia less attractive to PhDs due to the relative lack of these job qualities, they also decrease job satisfaction.

6.4.3.3. Satisfaction with terms of employment

A temporary contract (both tenure track and without the prospect of permanence) negatively influences satisfaction with terms of employment. A supervisory role increases satisfaction, as does having a mentor in the current job, and working outside academia. The latter mirrors Di Paolo's finding (2016) that PhDs outside academia are more satisfied with their pecuniary rewards. A job at bachelor level or lower in turn negatively influences satisfaction. Also for terms of employment a longer time in job decreases satisfaction: the hangover effect (Boswell et al., 2009; Lawler et al., 1975; Vroom & Deci, 1971).

6.4.3.4. Satisfaction with work-life balance

Having a tenure track contract negatively influences job satisfaction with work-life balance, as does having a humanities PhD, and having a job at professional degree level. The negative effect of having a tenure track contract is likely to be a result of the pressure to succeed when having such a contract. A likely explanation for those with a job at professional degree level having lower job satisfaction is that many of these PhDs are medical doctors, whose jobs are highly demanding and among whom stress and burn-out are relatively prevalent (Prins et al., 2010; Visser, Smets, Oort, & de Haes, 2003). In addition, female PhDs are less satisfied. This is a common finding in other studies on female and male academics (e.g., De Lourdes Machado-Taylor, White, & Gouveia, 2014). Finally, the longer a PhD has had a job, the less satisfied they are.

6.4.3.5. An extra variable: part-time employment

An important employment characteristic that could have influenced job satisfaction was whether a respondent had a full-time or part-time job contract (Conway & Briner, 2002). This question was only put to employees and not to self-employed respondents, for whom the distinction between part-time and full-time is problematic. Thus, we performed this linear regression without self-employed PhDs (Table S3). The results show that most effects remain statistically significant. Most importantly, the negative effects of the different types of temporary contracts on job satisfaction, particularly with terms of employment, but also with job content and work-life balance are also apparent in the second model. Part-time employment itself negatively influences satisfaction with terms of employment.

6.4.3.6. Overall effect of temporary employment on job satisfaction

We now make a complete assessment of the effect of temporary employment on job satisfaction. The largest effect is on satisfaction with terms of employment: in a simple comparison, the job satisfaction of PhDs on temporary contracts is lower than that of their peers on permanent contracts, unsurprisingly especially regarding job security. In this simple comparison, PhDs on temporary contracts are actually *more* satisfied with one of the aspects of job content, namely the intellectual challenge in the job. The lower satisfaction of PhDs with terms of employment in the simple analysis when employed on a temporary contract, is counteracted by a slightly higher satisfaction with the intellectual challenge in the job. However, we also found that when other factors, such as the sector of employment and level of the job are controlled for, there is no positive effect of temporary contracts on satisfaction with job content. Instead, temporary contracts (without prospect of permanence) turn out to be a slight *negative* influencer of satisfaction with job content. This is due to the role that sector of employment and required education level of the job play. Many recent PhDs on a temporary contract work in academia, where they have a higher chance to work on their level of educational attainment than their peers outside academia. When the level of the job is controlled for, the "positive" influence of temporary employment found in a simple comparison disappears.

6.4.4. Effect of employment status on personal life

The respondents were also asked what effects their type of employment contract had on their personal lives. Items were the ability to obtain a mortgage, the stability of their family lives, and the possibility to start a family. PhDs on a permanent contract were asked to which extent their contract had positively influenced these items and PhDs on a temporary contract to which extent it had negatively influenced them. The type of contract has the largest effect on the ability to obtain a mortgage. Four in ten PhDs on a temporary contract say their contract type has "much" or "very much" negatively influenced this ability. For the ones on a permanent contract this share is even higher: seven in ten say their permanent contract has positively influenced the ability "much" or "very much". With respect to the stability of family life and the possibility to start a family the effects are smaller, but still considerable: roughly a third of PhDs on a temporary contract say this contract "much" or "very much" negatively influenced their families. Men and women do not differ in a statistically significant way. As PhDs in academia are more prone to have a temporary contract, the effects of temporary contracts on personal lives are particularly pronounced in academia.

6.5. Conclusions and policy implications

According to dual labor market theory, temporary employment negatively affects the job satisfaction and well-being of workers, and disparities between workers on temporary contracts and those on permanent contracts tend to persist. However, it is also hypothesized that the highly educated may be exempt from this negative effect, and may use temporary jobs as a stepping stone to permanent employment.

Our analysis shows that for PhD graduates, temporary jobs are not "bad" jobs in the true sense of the word: if anything, PhDs on a temporary contract are *more* satisfied with job content. But, when we control for sector and job level, we find a negative influence of temporary employment on satisfaction with both job content (small effect) and terms of employment (larger effect). This shows that a negative effect of temporary employment also exists for (recent) PhD graduates, the highest educated persons in the labor force. Our findings are in line with Bertrand-Cloodt et al. (2012) and Van der Meer and Wielers (2014), who found that the highly educated (those with a university degree) are not exempt from the negative effects of temporary employment. We expect this is because temporary employment can lead to insecurity about career prospects, which in turn affects job satisfaction, as also found by Van der Weijden et al. (2016) among postdoctoral researchers (by definition employed on a temporary contract). As such, on the whole the PhDs studied here do not appear to experience a balanced psychological contract as found by Lam and De Campos (2015). However, further qualitative research would be needed to study which psychological contract PhDs experience with their employers, whether subgroups can be discerned, and whether the effects of temporary employment differ by psychological contract. Finally, we find a negative effect of temporary employment on the personal lives' of recent PhD graduates.

In conclusion, temporary employment negatively influences the job satisfaction of recent PhD graduates. Temporary contracts are much more prevalent in academia than outside it, making this effect especially important for the human resource management at universities and other academic institutions. Our results strongly suggest that whereas universities offer jobs that satisfy PhDs intellectually, they could much improve their relative attractiveness on the labor market by increasing the share of permanent contracts and contracts with the prospect of permanence to levels comparable to those in other sectors. Furthermore, since we found that almost a quarter of PhDs indicate they work below PhD level, we may conclude that there is a mismatch between the number of PhD conferrals and the demand for PhD graduates outside academia, where PhDs are overqualified for the labor market. This mismatch may well be exacerbated by the current growth of the number of PhDs (Association of Dutch Universities, 2016).

However, the mismatch may also lie in the types of skills obtained during a PhD trajectory in the Netherlands, and actually concern an *under*qualification. To check this, the match between acquired and required skills for various job types has to be studied. Actually, in our survey, we also collected information on the extent to which PhDs developed certain skills during their PhD and to which extent they need them in their current job. Preliminary data (to be reported elsewhere) show that research skills are overdeveloped by PhDs outside academia, but personal effectiveness, management and communication skills severely underdeveloped. This means that not only are PhDs working at bachelor or master level overqualified (looking purely at their degree), they are also underqualified, as they did not develop the skills needed for their current job in their doctoral training. This, too, could have a negative effect on job satisfaction. Thus a major policy implication is that Dutch universities should broaden their doctoral training to not only include the development of research skills, but also skills in other areas.

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6

CHAPTER 7

Effects of appointment types on the availability of research infrastructure, work pressure, stress, and career attitudes of PhD candidates of a Dutch university

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Abstract

Several types of PhD candidates exist in the Netherlands, based on how they are remunerated. The default remuneration is through employment by the university, which gives PhD candidates a salary, benefits, and legal protection through collective labour agreements. We call this group “internal” PhD candidates. However, there is also a large, heterogeneous group of “external” PhD candidates, who are not employed by the university and may be funded through scholarships (usually from foreign governments or funding organizations), or who do a PhD next to another job. In this study, we compare the experiences of internal and external PhD candidates by a survey among 218 PhD candidates of a Dutch university. Several aspects of the research infrastructure were assessed: financial situation, supervision, and access to office facilities. Furthermore, we measured work pressure, stress, and career attitudes. We found PhD candidates to be quite satisfied with their PhD on the whole, but regarding many infrastructural aspects, externals were at a disadvantaged position. They have less funding for research, a (much) lower personal income, and less access to office facilities such as a desk and a computer. Furthermore, they experience stress more often than internals. Externals are slightly more positive about their career prospects in academia than internals, but this difference is not statistically significant. Our findings indicate that type of appointment affects the PhD experience in the Netherlands, with non-employed PhD candidates at a disadvantaged position compared to employed PhD candidates.

7.1. Introduction

In the Netherlands, there are several types of PhD candidates. These can be distinguished along two lines: type of appointment and working full-time or part-time on the PhD. This results in four groups of PhD candidates: (1) employees with PhD research as their main task ("assistants-in-training" or *AIO's*), (2) other types of university employees who work part-time on the PhD next to other tasks, (3) non-employed PhD students for whom the PhD is the main task, usually non-Dutch PhD students with a scholarship (scholarship PhD students or *beurspromovendi*), and (4) other non-employed PhD students, for whom the PhD is not the main task and who usually do research next to another job (external PhD students or *buitenpromovendi*; Vereniging van Nederlandse Universiteiten [2013]).[1]

This classification reveals that different types of legal status and remuneration exist for a group that is essentially expected to deliver the same output: a doctoral dissertation. To our knowledge, no previous studies have been performed into how the type of appointment affects the experience of PhD candidates. Our study fills this gap by assessing the effect of appointment type (i.e., employed by the university [categories 1 and 2] vs. not employed by the university [categories 3 and 4]) on the availability of research infrastructure, work pressure and stress, and career preferences and perception of career prospects. These results are discussed in the context of the discussion on increasing precariousness of academic careers (including the careers of those past the PhD stage).

7.2. Literature background

7.2.1. Contingent academic careers?

In many countries, the academic career system has been changing. The "traditional" academic career of permanent (or tenured) faculty positions is giving way to careers of successive contingent positions (Schuster & Finkelstein, 2006, pp. 323-325). For example, in the United States there is an increasingly dual labor market of positions on the tenure track (typically research intensive positions) and positions off the tenure track (typically more teaching oriented), with little opportunities to move from "off" to "on" (Schuster & Finkelstein, 2006, pp. 217-223). In addition, there has been a large growth in the number of postdoctoral positions, which are temporary positions for (recent) PhD graduates. For example, in the

[1] Please note that this is a high-level classification of PhD statuses in the Netherlands, and individual circumstances vary, especially for non-employed PhD students. For example, whereas non-employed PhD students for whom the PhD is the main task are often funded through scholarships, they may also obtain funding by finding part-time employment or from sources other than employment (own savings, family, or retirement benefits).

United States the number of postdoctoral researchers more than tripled from 1979 (18,101) to 2013 (61,942; NSF, 2015, Table 27), a much larger increase than the increase in the number of traditional, full-time faculty positions, which increased from 146,000 in 1969 to 205,000 in 1998 (Schuster and Finkelstein, 2006, p. 46).

In Europe, the shift in academic appointments and contracts is also observed (e.g., Musselin, 2005; Enders & Musselin, 2008). In Germany, the opportunities for temporary positions at universities have only increased since the 1950s, whereas the opportunities for permanent positions have been decreasing since 1975 (Waaijer, 2015). In Portugal, only 22 per cent of academics are tenured (Carvalho, Cardoso, & Branco Sousa, 2014). This figure is 38 per cent for academic staff at Dutch universities (VSNU 2015). These career prospects affect academics: Höge, Brucculeri, & Iwanova (2012) showed that temporary employment among postdoctoral researchers in Germany, Austria and the UK decreases well-being due to insecurity. Among PhD graduates in the Netherlands, temporary employment decreases the job satisfaction (Waaijer, Belder, Sonneveld, van Bochove, & van der Weijden, 2016). These effects of temporary employment in academia are also seen as a problem by leading opinion makers in science, as they decrease the attractiveness of academic careers (Waaijer, 2013).

The previous paragraphs painted the picture of changing contractual arrangements for PhD-holding academics. Next to these changes, the contractual arrangements for PhD candidates have also been transformed. For example in Germany, from the 1960s, research affiliate (*wissenschaftliche Mitarbeiter*) positions were used not only to employ PhD-holding academics, but also persons working on their PhD (Bock, 1972, p. 205). In 1980, over half of these positions were permanent positions (Waaijer, 2015). However, by 1990 this percentage had dropped to one quarter. The Netherlands saw a similar development. For example according to the memoirs of a Dutch historian, in the 1970s one could be a "scientific employee" (*wetenschappelijk medewerker*) without having a PhD (Ebels-Hoving, 2011, p. 201-202). Indeed, in 1970 only a third of the academic staff in the Netherlands had obtained a PhD degree (CBS, 1973, p. 13). This changed with, among others, the introduction of a more formal PhD training in 1986. With this measure, a specific position was created for PhD candidates: the "researcher-in-training" (*assistent-in-opleiding* or *onderzoeker-in-opleiding*). In the following section we will describe the status of PhD candidates in the Netherlands in more detail.

7.2.2. The PhD in the Netherlands

At the time of the survey, if a university in the Netherlands wanted to appoint a PhD candidate paid from their own funds (including those obtained from third-party funding), an appointment as an employee was mandatory (Bartelse, Oost, & Sonneveld, 2007).[2] This was quite a unique situation, as in Europe the only other countries with such a system are Bosnia-Herzegovina and Denmark (European University Association, 2007, p. 29). Appointment was usually as an assistant-in-training (*AIO*) and on a four-year fixed-term contract. For such a position, a vacancy to which interested university graduates can apply is announced, after which job interviews take place and the most suitable candidate is selected.[3] Employee PhD candidates receive a salary, including a vacation and end-of-year bonus, and can incur benefits such as pension benefits, unemployment benefits, and maternity leave. Other types of university employees also enjoy these remunerations. However, other types of PhD candidates can also receive a PhD from Dutch universities. These are not paid directly by a Dutch university, but by another source. Scholarship PhD students typically receive a scholarship from a foreign government or funding organization (thus most scholarship PhD students do not have the Dutch nationality), and work on a PhD full-time. Often, the governments or funding organizations award such scholarships through competitive procedures. Scholarship PhD students are usually appointed as guest researchers by universities, as are external PhD students.

The Dutch PhD is characterized by a focus on doing research, which results in the writing of a dissertation, which takes the form of a book, or a collection of research papers already published in peer-reviewed journals. As in the Nordic countries, the former type of dissertation is common in the humanities and to a lesser degree the social sciences, whereas the journal-based dissertation is common in the natural sciences, life sciences, medicine, and some social sciences (Fridlund, 2010). A survey of recent PhD graduates from Dutch universities has shown that on average, PhD candidates have 4.25 papers accepted in international, peer-reviewed journals (Sonneveld, Yerkes, & van de Schoot, 2010, p. 50).

All PhD dissertations should meet the regulations of the university the candidate wishes to obtain the PhD degree from, regardless of appointment type. For every PhD degree the university that grants it obtains a fixed sum of income, which in 2014 was set to €95,434 (Government of the Netherlands, 2014). This sum is also incurred regardless of type of appointment. This implies that external PhD candidates who are successful in obtaining a PhD actually yield the university a net inflow of funds.

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[2] Very recently a plan to allow an experiment with student PhD candidates paid by universities themselves has been introduced by the Dutch Minister of Education, Science and Culture, starting January 2016 (Government of the Netherlands, 2015).

[3] Although quite often, positions are also filled by persons from the supervisor's own network, e.g., recent university graduates who did a successful bachelor's or master's research project with the supervisor.

PhD candidates' demographics have been evolving in the Netherlands, as they have in other countries. The share of women among doctorate recipients has been increasing, from less than a quarter in 1990 to almost half in 2010 (de Goede, Belder, & de Jonge, 2013, p. 5). Furthermore, internationalization has taken place: whereas in 2003 64 per cent of PhD candidates had the Dutch nationality, this percentage had dropped to 57 by 2011 (de Goede et al., 2013, p. 8). These developments mirror international trends regarding the achievement of gender balance (Auriol, Misu, & Freeman, 2013) and an increasing importance of foreign born in the academic workforce (e.g., Stephan, 2012, pp. 183-202 for the U.S.).

7.2.3. Previous studies on the effect of PhD status and other characteristics on the experience of PhD candidates

In this study, we compare PhD candidates who are employed by the university (further dubbed internals) to those who are not employed (further dubbed externals). We measure both objective outcomes, such as the frequency of meetings and availability of office facilities, and subjective outcomes, such as satisfaction with supervision. It must be borne in mind that job satisfaction is a relative measure rather than an absolute one. For example, both the expectations that an individual has of a job, and comparisons with other persons are important factors in determining job satisfaction. Persons with lower expectations of a job tend to report higher job satisfaction (affect theory; e.g., Poggi, 2010). This mechanism is also a reason why women are on average more satisfied with their job than men, despite objectively having worse jobs: they expect less (Clark, 1997). However, here it must be noted that highly educated women do not have these lower expectations and are actually *less* satisfied than men. Furthermore, individuals compare their own situation to other persons rather than deriving satisfaction from their objective situation: for example, if an individual finds they are remunerated less than comparable workers, this will decrease their satisfaction (equity theory; Clark & Oswald, 1996).

Our distinction of employed versus non-employed PhD candidates is not often used in the international literature, probably because few other countries have an employee status for PhD candidates. An exception is another Dutch study among PhD candidates of all Dutch universities, which found no or very small differences between employed PhD candidates and PhD candidates with a scholarship in their supervision (de Goede, Belder, & de Jonge, 2014). This study did find differences between the employed PhD candidates and PhD candidates who did a PhD next to another job; the latter have meetings with their supervisor less often. Studies from other countries find larger differences by mode of funding: for the United States, Ehrenberg and Mavros (1995) found that PhD students supported by fellowships or research assistantships finish their PhD faster than those supported by teaching assistantships, tuition waivers, and especially self-supporting PhD students. Among PhD students in the field of special education, Wasburn-Moses (2008) found that those with a grant are more satisfied with their doctoral experience, both with regards to how well prepared they feel for future positions, and overall. There have also been studies comparing the satisfaction of full-time and part-time PhD students, with part-time students usually doing their PhD next to other work. For Australia, Neumann and Rodwell (2009) compared the satisfaction of part-time to that of full-time research students (of whom the majority were PhD students). They found that part-time students are less satisfied with the research climate and infrastructure than full-time students. This might be related to how often PhD students see their advisor: Heath (2002) found that PhD students who meet with their supervisor at least fortnightly are more satisfied with the frequency of these meetings. Furthermore, they complete their PhD more often than those who meet every month or even less. A similar result was found by Harman (2003a) who found higher satisfaction with course experience when PhD students met with their advisor more often.

In our analysis, we adjust for other factors that might influence the PhD candidates' satisfaction with research infrastructure, the levels of work pressure and stress they report, and their career preferences and prospects where necessary, and possible. One category of such factors are personal characteristics. For example, Harman (2003a) found that in two Australian research-intensive universities, female PhD students are less satisfied with their supervision and the facilities they were offered. Furthermore, female PhD students have been found to experience more stress than their male counterparts (Toews et al., 1997). Nationality could play a role, as well: in Australia, domestic PhD students have a higher income at their disposal than international PhD students (Harman, 2003b). In addition, internationals have less financial support available for their research project. Interestingly, internationals reported a higher overall satisfaction with their experience as a PhD student in the same study. In Denmark, international PhD candidates experience their work environment as less stressful than their Danish counterparts (Kolmos, Kofoed, & Du, 2008). These latter two findings may be related to the literature on job satisfaction as described above: international PhD students may compare their situation to the situation of PhD students in their home country and feel that in comparison, their own situation is better, leading to high satisfaction levels.

There are also characteristics of the PhD that might influence the research infrastructure and experience of PhD candidates. For example, Barnes and Randall (2012) studied satisfaction among PhD students in the United States across different disciplines. Although the overall satisfaction with their doctoral experience did not differ significantly, the authors did find differences in satisfaction with specific aspects, such as whether PhD students received sufficient financial support. PhD students in engineering and physical science programmes that are research extensive are more satisfied than PhD students in research intensive humanities programmes.[4] In addition, the time into the PhD could influence our dependent variables. For example, Russo (2011) found that the percentage of PhD students who are satisfied or very satisfied with their graduate school experience went down from close to 80 in the first year to about 50 in the fifth year.

Next to satisfaction with research infrastructure, and work pressure, we assess the career preferences of PhD candidates, and determine whether these differ between types of appointment. Furthermore, we inquire how the PhD candidates perceive their post-PhD career prospects. Preferences for a career in academic research decrease during the PhD (Sauermann & Roach, 2012), but at the end of the PhD and onwards, there are still more PhD students and graduates who would like to continue working in academia than there are academic positions available (Stephan, 2012, p. 170). Career prospects in academia are seen as bad by many, including PhD students (Fox & Stephan, 2001; Waaijer, 2013; Waaijer, 2016). Here, we determine whether internal and external PhD candidates differ in their career preferences and perception of career prospects.

7.3. Data and methods

The data obtained in this study were obtained by a survey among PhD candidates at Leiden University, a large and broad research university in the Netherlands. In this section, we first describe which variables were included. Second, we expand on the survey methodology and description of respondents.

7.3.1. Variables

The main independent variable measured was type of appointment. Dependent variables were several aspects of the financial situation of PhD candidates, aspects of supervision, access to several office facilities, experienced levels of work pressure and stress, and post-PhD career attitudes. Other characteristics that are possible confounders in some of our analyses were measured as well: the PhD characteristics field of PhD and time working on PhD, and the personal characteristics gender and citizenship.

7.3.1.1. Type of employment

In our analysis, we distinguish the PhDs by two types of appointment: internal and external PhD candidates. Internals have an employment contract with Leiden University (categories 1 and 2 in the Introduction section); external PhDs do not (categories 3 and 4). Arguably, externals differ in source of funding and time allocation to the PhD, as our introduction

[4] In addition to comparing PhD students by research field, this specific study (Barnes & Randall, 2012) distinguished PhD students by institutional type, i.e., research intensive and research extensive.

explains. Externals who receive a scholarship and work on their PhD full-time might well have different needs and experiences than externals who have other employment and do a PhD next to that job. However, the latter group is limited in number (only six out of 65 externals are funded solely by another job). Therefore, we only distinguished internals and externals.

7.3.1.2. PhD characteristics

PhD characteristics that were measured were field of PhD, that is, the faculty in which respondents do their PhD. The faculties are Humanities, Law, Social and Behavioural Sciences (including the separate faculty of Public Administration), Science, and Other (including respondents from the faculty of Archaeology, and the ones who indicated they were from an "Other" faculty). The survey was also put to respondents from the Leiden University Medical Center (LUMC; which performs medical and biomedical research). However, the question which distinguishes internals and externals was whether respondents had an employment contract with *Leiden University* as a PhD candidate. Many candidates from the LUMC indicated they were external (as they would have been employed by the LUMC, not Leiden University). Therefore, the distinction between internal and external is problematic for medical PhD candidates and they were thus excluded from our analysis. Finally, we measured in which year of their PhD period respondents were.

7.3.1.3. Personal characteristics

Personal characteristics measured were gender and citizenship (Dutch or non-Dutch).

7.3.1.4. Financial situation

Aspects of the financial situation were the source of funding for the PhD research, whether sufficient funding was available for research material, research trips, and PhD-related training, and what the monthly disposable income of the PhD was (i.e., after tax deduction). The response categories to the latter question were "less than 500 euros", "500-1000 euros", "1000-1500 euros", and "more than 1500 euros".

7.3.1.5. Supervision

Variables of supervision included frequency of meetings with the main supervisor, rating of this frequency, and overall satisfaction with the supervision. Satisfaction was measured on a five-point Likert scale ranging from "very dissatisfied" to "very satisfied" throughout the questionnaire.

7.3.1.6. Offered facilities
Respondents were asked which of the following office facilities they had access to: an own desk, a desk shared with others, an own computer, a shared computer, free access to a telephone, free printing, and none of the above. The ones that had access to one or more facilities were asked how satisfied they were with their office space.

7.3.1.7. Work pressure stress
Respondents were asked to rate their work pressure, and how often they felt stressed at work. Furthermore, the respondents who felt stressed "sometimes" or more often were asked to tick which of sixteen items made them stressed.

7.3.1.8. Post-PhD career
Respondents were asked whether they would like to continue working in academia/research after their PhD. The ones who would like to were asked how they rate their career prospects in this sector.

7.3.2. Survey methodology and description of respondents
The survey was sent to members of the Leiden PhD Association (LEO) and to the Leiden academic network of the 2012 LEO board. The survey was open for almost two months: from 23 November 2012 until 21 January 2013. The complete questionnaire can be found in appendix 6. A total of 218 responses from Leiden University PhD candidates was received, after removal of duplicates. Duplicates were removed by checking the IP addresses of the respondents and whether answers given by the same IP address were identical or very similar. The most complete responses were kept.[5] No precise response rate could be calculated, as recipients of the survey invitation were encouraged to forward the invitation to colleagues and friends who were also doing a PhD at Leiden University.

Two thirds of PhD candidates were employed at Leiden University, and thus characterized as internals (Table 1). PhD candidates from the sciences constitute the largest group among the respondents, followed by the humanities, social and behavioural sciences, law, and other fields. Almost half of the respondents were in the first two years of the PhD at the time of the survey. Finally, the ratio between males and females is almost one-to-one, as is the ratio between Dutch and non-Dutch respondents. Some of these background variables are correlated with each other (Table S1 in appendix 6). For example, the largest group of internal respondents is working in the science faculty. The opposite is true for the humanities faculty, with many

[5] Not all responses with identical IP addresses were removed. In our original dataset, we found IP addresses with up to five responses. When assessing the answers of identical IP addresses, we found that these were often very different. Hence, it is likely that multiple PhD candidates used the same computer to fill in the survey.

external PhD candidates working in this faculty. Furthermore, non-Dutch PhD candidates are more likely to be externals.

Table 1. Descriptive statistics survey sample

Variables	%		%
PhD characteristics			
Employment		*Year of PhD*	
Employed by Leiden University	69	First year	20
Not employed by Leiden University	31	Second year	24
		Third year	19
Faculty		Fourth year	18
Humanities	34	Fifth year	11
Law	8	Sixth year or beyond	7
Science	44		
Social and Behavioural Sciences	12		
Other	2		
Personal characteristics			
Gender		*Citizenship*	
Male	51	Dutch	53
Female	49	Non-Dutch	47

N.B. Percentages may not add up to 100 due to rounding.

To determine whether specific groups of PhD candidates were overrepresented, or underrepresented, we performed a non-response analysis by type of employment contract and faculty. The ideal analysis would be to compare the percentage of internals and externals by faculty between the respondents and university totals. However, the university totals of internals (*AIO's*) are given in full-time equivalents, whereas those of externals are given in persons. Therefore, we calculated the share of PhD candidates by respondent or university group (Table S2). This analysis reveals a modest overrepresentation of humanities PhD candidates in our respondent set, and a modest underrepresentation of law PhD candidates.

7.4. Results

In this section, we describe the PhD candidates' research infrastructure and their satisfaction with it. Furthermore, we assess whether the various aspects of infrastructure are affected by the type of appointment of PhD candidates. We also describe the stress PhD candidates experience and what their career preferences are. The research infrastructure of PhD candidates consists of several aspects. In our study, we distinguish the financial situation, supervision, and (physical) facilities.

7.4.1. Financial situation

The first aspect of research infrastructure, and the main factor that separates internals and externals, is the mode of funding. Internals are paid by the university and are thus employees, whereas externals often are not. Hence, it makes sense for the source of funding to differ by type of employment. Indeed it does: internals are often funded through Leiden University or the Netherlands Organisation for Scientific Research (NWO), whereas externals are not. Externals, in turn, are more likely to be funded through a non-Dutch university, non-Dutch state authorities, or a non-Dutch private business. They also draw upon personal funds more, such as savings or funds from relatives or friends. Finally, they are more likely than internals to be funded through other employment next to the PhD position.

We assessed whether respondents have sufficient funding available for research (research material, research related training, and research trips), and compared internals and externals. Our results show that close to 90% of internals have sufficient funding for research available, compared to 30% of externals (Table 2; $p < 0.001$ in Mann-Whitney U test). Research funding for externals is often insufficient or completely absent. Hence, there is much more heterogeneity within the group of externals than in the group of internals, with the former being more likely to have insufficient research funding. This means, for example, that externals probably visit fewer conferences, which can be used to establish an academic network. Furthermore, the presentation of papers at conferences is shown to increase the visibility of these papers, especially if they were written by early career researchers (de Leon & McQuillin, 2015). These benefits are missed by PhD candidates who have insufficient finances to visit scientific conferences.

Table 2. Funding available for research

Funding for research	Internal	External	Total
		%	
Sufficient funding available	87	31	71
Funding available but not sufficient	11	38	19
No funding available at all	2	31	11

N. B. Percentages may not add up to 100 due to rounding.

Furthermore, we determined whether the personal income of PhD candidates differs by type of appointment. Internals tend to have a higher income than externals (Table 3; $p < 0.001$ in Mann-Whitney U test). Almost all internals have a net income of at least 1,000 euros per month, with 60% having an income of more than 1,500 euros. Conversely, close to 40% of externals have less than 1,000 euros per month to spend. Again, there is much more heterogeneity in the group of externals than in the group of internals. Our findings are in line with those of Sonneveld et al. (2010, p. 77) who found that *AIO's* have a (much) higher income than scholarship recipients.

Table 3. Monthly disposable income

Income	Internal	External	Total
		%	
Less than 500 euros	2	9	4
500-1000 euros	3	28	10
1000-1500 euros	34	40	36
More than 1500 euros	61	24	50

N. B. Percentages may not add up to 100 due to rounding.

7.4.2. Supervision

The second aspect of research infrastructure we describe, is supervision. We compared the frequency of meetings with the supervisor between internals and externals, and their satisfaction with this frequency. Externals meet with their supervisors less often (Table 4). They are also less satisfied with this frequency, but this tendency is not statistically significant. These results slightly resemble but are subtly different from those of Heath (2002) and Harman (2003a) who both found that PhD students were more satisfied with the frequency of supervisory meetings when the frequency is higher. We also determined the overall satisfaction with supervision and compared it between the two groups. Two thirds of respondents were "satisfied" or "very satisfied" (Table 5). No meaningful differences in satisfaction were found between internals and externals (p = 0.259 in Mann-Whitney U test).

Table 4. Frequency of meetings with main supervisor and satisfaction with frequency

Frequency	Internal	External	Satisfaction	Internal	External
	%			%	
Daily	3	2	Far too high	0	2
Weekly	28	17	Too high	1	6
Once every two weeks	26	24	Exactly right	74	55
Monthly	20	17	Too low	22	26
Once every two months	15	15	Far too low	4	11
Once every six months	4	13	*p-value*	*0.260*	
None	1	4			
Other	4	9			
p-value	*0.030*				

N. B. Percentages may not add up to 100 due to rounding. P-values from Mann-Whitney U test; for test on frequency of meetings, the answers "other" were removed.

Table 5. Overall satisfaction with supervision

Overall satisfaction	Internal	External	Total
		%	
Very satisfied	28	23	26
Satisfied	43	42	43
Neither satisfied nor dissatisfied	19	19	19
Dissatisfied	7	11	9
Very dissatisfied	2	6	3

N. B. Percentages may not add up to 100 due to rounding.

7.4.3. Facilities

A third aspect of research infrastructure concerns the facilities PhD candidates have at their disposal. For the office facilities mentioned above we compared the shares of internals and externals who have access to them. Furthermore, we determine how many PhD candidates have no such facilities at their disposal. Our comparison between internals and externals shows that externals less often have an own desk, an own computer, free printing, and free telephone facilities (Table S3). They much more often than internals have access to none of the listed facilities. However, the fact that they have fewer facilities might not be due to their type of appointment *per se*, but to other factors. For example, amongst external PhD candidates, the share of candidates from the humanities and the law faculty is much higher than amongst internals (Table S1). Hence, it might be the case that the former faculties offer fewer facilities to all PhD candidates, internal as well as external, than the science faculty. A similar argument could be made for nationality; in principle, Dutch PhD candidates are not remunerated through scholarships but through employment. Therefore, we performed a logistic regression on all facilities offered by type of appointment and the control variables faculty, year of PhD, gender, and nationality. This analysis shows that for all facilities to which internals had access more often than externals, the type of appointment independently affects whether an own desk and an own computer are offered (Table 6), as well as all other facilities to which internals had access more often than externals (Table S4).

Table 6. Logistic regression on availability of own desk and own computer by employment status, controlling for other variables

	Own desk		Own computer	
	B (S. E.)	p-value	B (S. E.)	p-value
Constant	0.77 (0.61)	0.202	0.49 (0.56)	0.384
Internal (dummy)	2.15 (0.50)	< 0.001***	1.82 (0.45)	< 0.001***
Faculty (ref. is humanities)				
Law	0.91 (0.88)	0.302	1.12 (0.84)	0.186
Science	0.88 (0.52)	0.091	0.52 (0.45)	0.247
Social and behavioural sciences	-0.63 (0.62)	0.311	-0.05 (0.57)	0.936
Year of PhD	-0.22 (0.14)	0.127	-0.08 (0.13)	0.529
Female (dummy)	-0.60 (0.45)	0.180	-0.62 (0.40)	0.124
Dutch (dummy)	0.06 (0.47)	0.900	-0.45 (0.43)	0.293
Cox & Snell R^2	*0.194*		*0.146*	

We also asked the respondents who have one or more of the listed facilities at their disposal how satisfied they are with these facilities. Externals not only have facilities at their disposal less often, they are also less satisfied with the offered office facilities (Table 7; $p < 0.001$ in Mann-Whitney U test). Please note that these are only the answers of the 75 per cent of externals who do have one or more facilities at their disposal; respondents who did not have any facilities were not asked the question how satisfied they are with the offered facilities (as they do not have them).

Table 7. Satisfaction with facilities

Satisfaction	Internals	Externals	Total
		%	
Very satisfied	43	39	42
Satisfied	51	36	47
Neither satisfied nor dissatisfied	5	16	8
Dissatisfied	1	2	2
Very dissatisfied	0	7	2

N. B. Question only asked to respondents who did not tick "none" when answering the question which facilities they have at their disposal. Percentages may not add up to 100 due to rounding.

Our results are in apparent contrast with de Goede et al.'s (2014) who did not find differences between the satisfaction of employed PhD candidates and PhD candidates on a scholarship, the main group of PhD candidates in our sample of externals. However, they did not assess the material aspects of research infrastructure (the financial situation and access to office facilities). It is in those aspects that we find large differences between the two groups. Furthermore, they also state in their report that they have probably "only reached scholarship PhD candidates who are visible to university administrations, whose daily work practice may hardly differ from employed PhD candidates" (de Goede et al., 2014, p. 45; own translation). On the other hand, we contacted PhD candidates through an association of PhD candidates, allowing us to reach PhD candidates invisible to university administration. Our results are more similar to those of Neumann and Rodwell (2009), who found that part-time research students are less satisfied with research infrastructure (which includes "working space, technical support, computing facilities and necessary equipment, as well as financial support for research", with the difference that they compared full-time to part-time students, whereas we compare PhD candidates employed by the university to those who are not.

7.4.4. Pressure and stress

Respondents were asked how they rate their work pressure. Half indicated this pressure is "normal", four in ten said it is "high", and a mere four per cent said it is "too high" (Table 8). Though no statistically significant differences are observed between internals and externals (p = 0.497 in Mann-Whitney U test), in case of those experiencing a very high pressure, the difference between externals (8%) and internals (3%) is quite suggestive. In frequency of stress that PhD candidates experienced we *do* find statistically significant differences between internals and externals (Table 9; p = 0.024 in Mann-Whitney U test). Externals more often indicate they are "always" or "often" stressed. Other factors, such as year of PhD, faculty, gender, and nationality could also influence the experience of work pressure and stress. Therefore, a binary logistic regression including both type of appointment and these other factors was run on experiencing high pressure, and being stressed often.[6] Our results show that type of appointment indeed does not affect the rating of work pressure, but *does* have a significant effect on the frequency of stress: internals are less likely to experience stress often, also when controlling for these other factors (Table S5). However, it must be borne in mind that the explained variance is low (Cox & Snell R^2 = 0.096). This means that type of appointment only explains the frequency of stress to a small extent, but does affect it independently from the other factors commonly associated with stress that we measured. The perception of work pressure was also only explained by the included independent variables to a small extent (Cox & Snell R^2 = 0.109). However, an interesting finding is that *ceteris paribus*, women experience high work pressure more often than men, a finding similar to the effect found by Toews et al. (1997).

[6] Running ordinal regressions on pressure and stress with five answer categories resulted in too many empty cells. Therefore, answer categories were combined into dummies of "high pressure" (rating of pressure as "high" or "too high") and "often stressed" (rating frequency of stress as "often", "very often", or "always").

Table 8. Work pressure

Work pressure	Internal	External	Total
		%	
Too high	3	8	4
High	43	32	40
Normal	52	55	53
Low	2	6	3
Too low	0	0	0

N. B. Percentages may not add up to 100 due to rounding.

Table 9. Frequency of stress

Frequency of stress	Internal	External	Total
		%	
Never	7	11	8
Sometimes	53	28	46
Often	23	30	25
Very often	14	17	15
Always	2	13	5

N. B. Percentages may not add up to 100 due to rounding.

Our findings of type of appointment influencing frequency of stress but not work pressure would appear to contradict each other. However, a high work pressure does not have to lead to high stress levels. Out of the 74 respondents who reported “high” work pressure, one said they “never” feel stressed, and 27 said they only “sometimes” feel stress, which makes for a total of 38 per cent of respondents who are not often stressed while at the same time reporting high work pressure. The other way around is also true: a high frequency of stress is not always accompanied by high work pressure. Out of the 53 respondents who were “often” stressed, 15 reported “normal” or even “low” (in one case) work pressure.

The most important sources of stress for the respondents are pressure to publish, deadlines, difficulty of work, amount of work, contact with managers or supervisors, and interruptions during work (Table S6). The main non-work related stressor are drastic personal events. For internals, pressure to publish and teaching duties are sources of stress more often than for externals (Table S6). Logistic regression with type of appointment, faculty, gender, nationality and year of PhD as independent variables shows that type of appointment is only an independent predictor of stress due to teaching, not of stress due to publication pressure. For externals, contact with managers or supervisors, and with colleagues are stressors more often than for internals, but after controlling for the other variables in a logistic regression, type of appointment was found to have an independent effect only on stress due to managers or supervisors.

7.4.5. Post-PhD career

Respondents were asked what their plans for their post-PhD career are; whether they would like to work inside or outside academia/research. About sixty per cent would prefer to work in academia or (non-academic) research after the PhD; thirteen per cent would not. Another quarter does not know yet. This strong preference to work in academic or non-academic research was also found in a study among all PhD candidates in the Netherlands (de Goede et al., 2014). Studies from other countries have found an even stronger preference for research among postdoctoral researchers (Fitzenberg & Schulze, 2014; Puljak & Sharif, 2009). A greater share of externals would like to work in academia or research, and a greater share of internals do not know yet, but these differences are not statistically significant ($p = 0.078$ in Pearson's chi-squared test of independence).

Respondents who would like to work in academia or research were asked how they rate their career prospects in this sector. Many found them "difficult" or even "very difficult" (Table 10). Crosstabulation shows that internals rate the prospects as worse than externals, but this difference is not statistically significant ($p = 0.399$ in Mann-Whitney U test).

Table 10. Perception of career prospects

	Internal	External	Total
		%	
Very easy	0	13	4
Easy	7	3	5
Neither easy nor difficult	28	31	29
Difficult	57	38	51
Very difficult	8	15	11

N. B. Percentages may not add up to 100 due to rounding.

7.5. Discussion and conclusions

Many countries have witnessed shifts in academic appointments such as a shift from many permanent positions for university researchers to a larger share of contingent, temporary positions, which has affected the employment conditions in academia (Schuster & Finkelstein, 2006, p 323-325). The Netherlands is no exception to this trend. Fitting with this trend of more contingent careers is the shift from employed to student PhD candidates, which has taken place in several countries. Although in the Netherlands, at the time of the survey, universities had to employ PhD candidates financed through their own funds, there were also many PhD candidates who were not employed by the university, such as scholarship PhD candidates and PhD candidates doing a PhD next to a main job. Our results show that type of appointment does not significantly influence the immaterial infrastructure of PhD candidates (supervision), but does strongly negatively affect material infrastructure (financial situation and office facilities). Considering the fact that most of the externals in our sample are funded through scholarships and not through other employment, it is likely that these are PhD candidates who work full-time on their PhD. In this light, it is especially remarkable that many important aspects of research infrastructure are not available to so many of them.[7]

In addition, externals who do have access to at least some office facilities, are less satisfied with them. Economic psychology shows job satisfaction of individuals to be related to expectations (Poggi, 2010) and to be affected by comparisons to others (Clark & Oswald, 1996). Quite probably, the lower satisfaction of externals is at least partly due to the fact that they compare their situation to that of internals, which is objectively better. In this light, it would be interesting to study additional aspects of job satisfaction, such as with remuneration and embeddedness in the department.

Our results also show that externals are stressed at work more often than internals. An interesting follow-up question would be to see if their higher stress levels could be caused by the lesser availability of material infrastructure, or are caused by other factors. Another striking finding in our study was that female PhD candidates were more likely to report high work pressure than male PhD candidates. Again, a follow-up question that warrants further investigation but cannot be answered by a survey study like ours, is to investigate the reasons for the higher work pressure experienced by females.

Of course, our conclusions are based on data from a single university only. However, the PhD candidate population in Leiden does not differ from that in the other Dutch universities: everywhere a considerable share of PhD candidates is university employee but there are also many external PhD candidates. Local conditions for PhDs may vary somewhat because of policy differences, but our findings are quite comparable to what PhDs from other universities report in national meetings. Consequently, by and large our results are quite likely to represent the situation of PhD candidates in all Dutch universities.

[7] In 2015, two years after the LEO survey on which the findings of our paper are based, several questions especially directed at PhD candidates were included in the university's employee monitor. The results of this monitor show that satisfaction with office facilities did not differ between internal and external PhDs (Smeenk & Mariën, 2015), which suggests that office facilities have indeed improved for externals. However, no questions were included on the availability of office facilities, categories of internals and externals were slightly different and no distribution of the data was shown, making it difficult to compare results between our survey and the employee monitor.

In conclusion, on the whole, the surveyed PhD candidates are quite satisfied with their PhD experience. Strikingly, however, PhD candidates who are not employed by the university are at a disadvantaged position with respect to financial situation, offered facilities, and experienced work stress. Hence, type of appointment affects several aspects of the PhD. This shows that precarious working conditions influence the way PhD candidates conduct their research projects.

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CHAPTER 8

The role of gender in the employment, career perception and research performance of recent PhD graduates from Dutch universities

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Abstract

Recent decades have seen a sharp increase in the number of female PhD graduates in the Netherlands. Currently, the share of females among newly graduated PhDs is almost on par with that of males. A considerable body of scientific studies has investigated the role of gender in the academic workplace. However, the role of gender in the careers of all PhD graduates, including those outside academia, has been studied less. In this study, we investigate gender differences in type of job, occupation, career perception and research performance of recent PhDs. The study is based on a survey of persons who obtained a PhD from one of five Dutch universities between 2008 and early 2012. We show that gender differences in post-PhD careers are non-existent in some aspects studied, but there are small differences in other aspects, such as sector of employment, type of contract, involvement in teaching and management, and career perception. In contrast, male and female PhDs differ sharply on two factors. The first is field of PhD, females being heavily underrepresented in engineering and the natural sciences. The second is part-time employment, females being much more likely to work part-time than males, especially if they work in the Netherlands. In later career stages, the combination of the small and large differences can be presumed to affect the career progression of female PhDs through cumulative disadvantage.

8.1. Introduction

The pool of highly educated women (with a master's or doctoral degree) is larger than ever. In many countries, numbers of female PhD graduates have increased much more than numbers of male PhDs over the past decades, women receiving 47 per cent of 2012 doctoral degrees in the European Union (European Commission, 2015). The Netherlands is no exception to this trend (de Goede, Belder, & de Jonge, 2014; Statistics Netherlands, 2014a). This raises the question whether the career interests of and opportunities for female PhDs follow the same trend towards gender equality as the percentage of PhDs. Although a sizeable body of scientific literature on the role of gender on academic careers exists, the topic of gender differences in the post-PhD careers of *all* PhDs, including those outside academic research, remains underexplored. In this study, we provide evidence on gender differences in job type, occupation, career perception and research performance of recent PhDs from Dutch universities.

First, we will give a short overview of the existing literature on gender and (academic) careers. Women are still heavily underrepresented in higher positions, both in academia and in other sectors (Hoobler, Lemmon, & Wayne, 2011; Landelijk Netwerk van Vrouwelijke Hoogleraren, 2015; Shen, 2013). One explanation for this is the pipeline argument, which says that when the number of women among entrants rises, so will the share of women in top positions. In science, technology, engineering and mathematics (STEM), this certainly holds true, as females are heavily underrepresented in these fields, for example in the United States, Canada and the Netherlands (Hango, 2013; National Science Foundation/National Center for Science and Engineering Statistics, 2015; Statistics Netherlands, 2015). However, the pipeline argument alone cannot explain the underrepresentation of women in top positions in academia and business (Hoobler et al., 2011). For the underrepresentation of women in top academic positions, many other explanations have been proposed, including but not limited to gender differences in career interest, differences in performance and (implicit) gender bias in hiring, promotion and research funding decisions. In many cases, gender differences are quite small, but over time these differences lead to a cumulative disadvantage for female academics (Jacobs, 1996).

Job activities differ by gender: female faculty are more involved in teaching, whereas their male counterparts are more likely to focus on research (Bellas & Toutkoushian, 1999; Schuster & Finkelstein, 2006, p. 86). This may also affect promotion decisions, as these are often based on research performance (van Arensbergen, Hessels, & van der Meulen, 2013; van den Brink & Benschop, 2012a). Research production also differs, with female scientists lagging behind their male counterparts (Larivière, Vignola-Gagné, Villeneuve, Gelinas, & Gingras, 2011;

Prpić, 2002). However, this result is obtained without a correction for differences in hours worked. The stage of the career may be important, as young social scientists in the Netherlands do not show gender differences in production (van Arensbergen, 2014). In contrast, in the same group ten years later, the total productivity of males was higher than that of females, suggesting that whereas production is similar for male and female academics in early career stages, in later career stages gender differences occur (van den Besselaar & Sandström, 2015). When it comes to citation impact, most studies find small or no differences between male and female scientists (Bordons, Morillo, Fernandez, & Gomez, 2003; Larivière et al., 2011; van den Besselaar & Sandström, 2015).

There is also evidence for gender bias in hiring, promotion and funding decisions. Female academics are less likely to be hired or promoted than male academics, even with the same job experience and accomplishments (Austen, 2004; Cooray, Verma, & Wright, 2014; Steinpreis, Anders, & Ritzke, 1999; Ward, 2001). In hiring processes in the Netherlands, gender also plays a role (van den Brink, Brouns, & Waslander, 2006). However, the evidence is conflicting, others finding no influence of gender in career progression (Ginther & Kahn, 2009; Kaminski & Geisler, 2012). When it comes to the role of gender in research funding, the scientific literature is also divided. Based on a large review of the literature Ceci and Williams (2011) argue that gender differences in funding are small, or even non-existent. In contrast, others find that female scientists are in a disadvantaged position, with women receiving less funding in total (Larivière et al., 2011), receiving smaller grants (Shen, 2013), and having a smaller chance of success when submitting a grant proposal (European Research Council, 2014). In the Netherlands a recent study found gender bias in the allocation of grants from the most important national person-oriented research funding schemes (van der Lee & Ellemers, 2015). However, this finding was later disputed (Volker & Steenbeek, 2015).

As such, there is quite some literature on gender differences among academic researchers, but less is known about gender differences in the post-PhD careers of all PhDs. There is some evidence on the subject: in the Netherlands, females are less likely to work as a researcher than males, are also less likely to work in the business enterprise sector, but more likely to work in the private non-profit sector (Maas, Korvorst, van der Mooren, & Meijers, 2014). In the U.S., too, females are less likely to work in the business sector; there they are more likely to work in the academic sector (Bender & Heywood, 2006). These breakdowns, however, do not take into account time since PhD. Since the share of male PhDs was much higher in the past, lumping PhDs of several cohorts together may sharply bias findings. A study of a more homogeneous group of recent PhDs in Denmark found no effect of gender on the sector of employment (Bloch, Krogh Graversen, & Skovgaard Pedersen, 2015). The activities performed in PhDs' work also differ between women and men, with female PhDs in Australia being more involved in teaching and advising or mentoring students and male PhDs being more involved in research, supervising or management, product development and the commercialization of research products (Dever et al., 2008, pp. 33-34). Earlier, Fox and Stephan (2001) found that female doctoral students at U.S. universities are more interested in academic teaching than their male counterparts.

With respect to type of contract, female PhDs from Australian universities are slightly more likely to have a temporary contract (Dever et al., 2008, p. 29). For the Netherlands, Sonneveld, Yerkes and Van de Schoot (2010, p. 96) found that females are more likely to have a temporary contract when working outside academia. Female PhDs are employed part-time much more often than males, especially in Germany, Belgium and the Netherlands (Auriol, Misu, & Freeman, 2013, p. 17). Nevertheless, in the Netherlands part-time employment among female PhDs is much lower than among female master graduates, female PhDs working on average almost four hours per week more than female master graduates (Auriol et al., 2013, p. 17; van der Steeg, van der Wiel, & Wouterse, 2014). These gender differences also raise the question whether male and female PhDs perceive their career prospects differently. In the United States, Fox and Stephan (2001) found that male PhD students were more positive about their career prospects in industry or government than female PhD students, whereas females were more positive about career prospects in academic teaching.

In this study, we delve further into the role of gender in post-PhD careers, by investigating gender differences in the careers of recent PhDs from five Dutch universities.
We address the following research questions:

1. Does the type of job (sector of employment, level of job, and type of contract) of PhDs differ by gender?
2. Does the occupation of PhDs differ by gender?
3. Does the perception of career prospects differ by gender?
4. Does the (perception of) research performance differ by gender, i.e., do male and female PhDs receive research funding to the same extent, and do they perceive their scientific oeuvre differently?

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The Netherlands was chosen as a country of study as the share of females among PhD graduates is comparable to the EU-28 average and trends in the growth of PhD graduates, both male and female, also mirror the EU-28 average (European Commission, 2015). At the same time, the Netherlands has a relatively low share of women in higher academic and leadership positions (European Commission, 2015). Using a sample of recent PhDs makes it possible to study whether gender differences already occur quickly after the conferral of the PhD degree.

8.2. Data and methods

Below, we provide a summary of the survey methodology and measured variables. A more elaborate description of the survey questionnaire, methodology and variables is given in a working paper (Waaijer, Belder, Sonneveld, van Bochove, & van der Weijden, 2015).

The *survey sample* consisted of 2,193 PhD graduates who obtained a PhD from Utrecht University (a broad research university), Delft University of Technology (engineering and technology), Wageningen University (an agricultural university), or Erasmus University Rotterdam (focused on medicine and social sciences, especially economics and management) between April 2008 and March 2009 or from Leiden University (a broad research university) between January 2008 and May 2012. An invitation to the survey (which was open from 23 October 2013 until 21 January 2014) was sent through email or LinkedIn, in which the prospective respondents were informed on the purpose and content of the survey in the invitation, and strict confidentiality guaranteed, only aggregate results (impossible to trace back to individuals) to be published. Furthermore, a test of the survey showed the survey took 20 minutes to complete on average, which was also written in invitation letter, so the respondents would know which response burden to expect. In the online survey itself, the instructions made explicit it was possible to quit the survey. Up to three reminders were sent if respondents had not completed the survey. In total, 1,133 started the survey (52%), and 960 progressed to the final question (44%). Survey data were anonymized before analysis and the key to the respondents' names and unique survey analysis ID stored in a secured folder.

Non-response analysis showed that the respondents were representative of the survey set regarding gender, age, year of PhD, and city of PhD (Waaijer et al., 2015). However, Dutch nationals seemed to be overrepresented in the survey compared to the country of birth of the entire sample.

In this study, we used variables on type of job, perception of career prospects, research performance and personal characteristics. Three *sectors of employment* were distinguished: academic R&D (dubbed academia in the paper for brevity), non-academic R&D (dubbed non-academic research) and non-R&D (dubbed outside research). The classification of respondents into these categories was based on two variables: involvement in R&D and type of employer. We follow the Organisation for Economic Co-operation and Development's (OECD) typology of R&D: basic research, applied research, and experimental development (OECD, 2002). PhDs not involved in any of the three in their main job were classified as working outside research. PhDs in academia are PhDs involved in R&D and employed at a university, university of applied sciences or college, academic hospital, or research institute.

PhDs in non-academic research are PhDs involved in any type of R&D and working at another type of institution (e.g., at a private business [incl. an own business], government institution, non-academic hospital). Furthermore, respondents were asked whether they were working in or outside the Netherlands.

The *level* of the respondents' job was also determined, through two multiple-choice questions. Two aspects of job level were determined: whether respondents had a supervisory role, and the education level normally required for their job. The four education levels were bachelor or lower, master, PhD, and professional degree (e.g., medical degree). For the respondents with a job, we measured which *type of contract* they had. We distinguish five types of employment (contract): permanent contract, probation period of a permanent contract, tenure track contract, temporary contract without prospect of permanence, and self-employment. Furthermore, we asked employees whether they were employed full-time or part-time. Full-time was regarded as working the maximum number of hours possible according to the sector's collective labor agreement; part-time as less than this maximum. This choice was made because we expect a large share of PhDs work in environments where full-time employment is the norm (van den Brink & Benschop, 2012a). Here, we deviate from the standard Dutch classification that considers part-time employment as employment for fewer than 35 hours per week (Statistics Netherlands, 2009). However, this standard classification was mainly constructed in this way because the number of hours constituting full-time employment differs by sector. By asking respondents whether they work full-time according to their sector's collective labor agreement, we solve this problem. Furthermore, we developed a *classification of PhDs' occupations*.

Perception of career prospects was determined by asking respondents how they would rate "long-term career perspectives" and "the availability of permanent positions" in academia, non-academic research and outside research on a five-point Likert scale ranging from "very bad" to "very good". Furthermore, a few aspects of the PhDs' research performance were measured. We asked respondents whether they had *received a personal grant* for doing research. Respondents were also asked to rate their *perception of their own scientific oeuvre*, by indicating to which extent they agreed with the following statement: "my scientific oeuvre is good enough to build an academic research career on" (on a four-point scale).

In the survey, we also asked the respondents for their *gender* (female or male, with an explicit answer option in the survey not to tick one of the two). *Nationality* was measured as a dummy for high income OECD countries. The variable measures whether a PhD has the nationality from one of 21 OECD countries with a per capita Gross Domestic Product greater than $32,000 Purchasing Power Parity in 2012 (UNESCO Institute for Statistics, 2014). These countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom of Great Britain and Northern Ireland, and the United States of America.

We also measured the respondents' *age at the time of the survey*, whether they were *living with a partner*, and whether they had *children below the age of six*. In addition, we determined the *field of PhD* (medical and health sciences, natural sciences, social sciences, humanities, or engineering and technology) and *years since PhD*.

8.3. Results

8.3.1. Type of job

First, we looked at the type of job that PhDs had, and assessed whether there were gender differences. One aspect of job type is the *sector of employment*. Female PhDs were more likely than their male counterparts to work in academia (64% of females vs. 56% of males), whereas males were more likely to work in non-academic research (34% of males vs. 22% of females; $p < 0.001$ in Pearson's $\chi 2$ test of independence). A simple explanation for this fact may be that in fields where females are traditionally underrepresented (i.e., natural sciences, and engineering and technology), more PhDs will go into non-academic research. Among recent PhDs in the Netherlands, women are also underrepresented in engineering and technology (22% of PhDs in this field are female) and in the natural sciences (39% female). On the other hand, there is gender parity in the medical and health sciences (54% female), social sciences (52%) and humanities (47%). To assess the effects of gender distribution by field on sector of employment, we calculated what the sector of employment of male and female PhDs would have been if the gender distribution in all separate fields would have been the same as in the entire group of respondents. This decreased the gender differences slightly, but women were still more likely to work in academia and men more likely to work in non-academic research.

Second, we analyzed the *level* of the PhDs' job. Three aspects of job level were measured: the educational level normally required for the job and whether the PhD has a supervisory role. Over half of the respondents had a supervisory role in their jobs. Most worked at PhD level, but there was a considerable group working below this level of educational attainment: close to a quarter. There were no statistically significant differences in job level between female and male PhDs, which shows that at early career stages, gender does not influence the level of the job.

Third, we analyzed whether gender affects the *type of contract* of recent PhDs. We found no large differences between the percentages of females and males in a probation period (both 3%), on a tenure track contract (7 vs. 6%) or being self-employed (6 vs. 8%). However, there were large differences between females and males regarding permanent employment and temporary employment without prospect of permanence: a smaller share of females was employed on a permanent contract (45%, vs. 55% of the males; $p = 0.002$ in Pearson's $\chi 2$ test of independence), and a larger share on a temporary contract without prospect of permanence (39%, vs. 29% of the males; $p < 0.001$).

It may be that other factors underlie this difference, such as sector of employment (women are more prone to work in academia, where temporary contracts are more prevalent) or field of PhD (men are more likely to do a PhD in engineering and technology, where employers may offer job security to be an attractive employer to scarce talent). Therefore, we performed a logistic regression for temporary employment without prospect for permanence on gender, other personal characteristics, sector of employment, time since PhD, and the field of PhD. As the effects of having children may be different for males and females, we also included an interaction term between gender and children.

The results show that after controlling for these other factors, gender did not influence the likelihood to have a temporary contract without prospect of permanence (Table 1). Having children below the age of six was associated with a smaller likelihood. Although there was a slight interaction effect between gender and children, this effect was not statistically significant. Instead, the sector of employment did influence this likelihood, as outside academia a temporary contract was much less likely than in academia. Time since PhD was also an important factor: the longer it was, the smaller the likelihood of a temporary contract. Unsurprisingly, older PhDs were less likely to have a temporary contract. Furthermore, PhDs from the medical and natural sciences, and the humanities, were more likely to have a temporary contract than engineering PhDs. Thus, it is through sector of employment, field of PhD and personal characteristics that a larger percentage of females had a temporary contract than males.

Table 1. Effect of several employment, personal and PhD characteristics on the employment on a temporary contract without prospect of permanence

	B (S. E.)	p-value
Intercept	2.92 (0.90)	0.001**
Female	0.03 (0.25)	0.902
Children below 6	-0.69 (0.28)	0.014*
Female x children below 6	0.66 (0.38)	0.083
Nationality of high-income OECD country	0.46 (0.32)	0.158
Living with partner	-0.17 (0.24)	0.475
Age at survey	-0.09 (0.02)	< 0.001***
Years since PhD	-0.21 (0.08)	0.007**
Sector of employment (ref. is academia)		
Non-academic research	-2.02 (0.27)	< 0.001***
Outside research	-1.01 (0.29)	< 0.001***
Field (ref. is engineering and technology)		
Medical and health sciences	1.27 (0.42)	0.002**
Natural sciences	0.92 (0.42)	0.028*
Social sciences	0.18 (0.46)	0.705
Humanities	1.31 (0.47)	0.005**

*, **, and *** denote statistically significant difference of the independent variable at the 5, 1, and 0.1% levels, respectively. Analysis based on 657 observations.

We also looked at *part-time employment*. On the whole, a much larger share of female PhDs was employed part-time (Table 2; 34% of females vs. 12% of males). The sector with the largest share of part-time employment was "Outside research", followed by non-academic research and academia. Of male PhDs outside research, too, a relatively large percentage worked part-time. Among female PhDs, part-time employment was especially common for those with young children: 52% of females with children below the age of six worked part-time compared to 23% of women without young children. For males, these percentages were 15% for those with children below six and 11% without young children. In addition, working part-time was much more common in the Netherlands than outside it: 31% of the PhDs in the survey working in the Netherlands worked part-time, compared to just 6% of those working outside the Netherlands. This high figure is mainly due to female PhDs: 47% of females in the Netherlands worked part-time, compared to 17% of males.

Table 2. % of employees working part-time, by sector of employment and gender

	Male	Female	Total
		%	
Academia	10	31	20
Non-academic research	12	43	23
Outside research	26	41	34
Total	12	34	22

8.3.2. Occupation

So what did PhDs actually do in their jobs, i.e., what is their *occupation*? In official statistics, the classification of occupations that is used is the International Standard Classification of Occupations (ISCO-08) from the International Labour Organization (ILO, 2008). In this classification, most PhDs are classified into the main categories "professionals" and "managers". Further sub classifications are by field, e.g., science and engineering professionals, teaching professionals, etcetera. Unfortunately, this may be problematic for scientists who are involved in multiple activities, such as university research and teaching (which are two categories in ISCO-08). The same problem occurs when PhDs are involved in both consulting and teaching, or any other combination of activities that are grouped in different occupational categories. However, for PhDs it is not sufficiently fine-grained. Therefore, we developed our own classification of PhDs' occupations:

1. PhDs active in education (subdivided into non-academic level, at an institution for higher vocational education or at university level).
2. PhDs active in research (subdivided according to job level into junior [postdoctoral researchers, junior scientists and research assistants], senior [associate professors, full professors, senior scientists] and intermediate [associate professors, researchers (without prefix or suffix) and all other job titles].
3. Content specialists: professionals who do not perform research or teach, but use the knowledge they obtained during their educational training in their job (subdivided into consultants, policy advisors, four health care categories, lawyers and other legal professionals, and other content specialists).
4. PhDs active in management (subdivided into research management, general management and self-employed).
5. PhDs in other occupations.

In this classification, PhDs can be classified into multiple major categories, but only one sub category is possible. Examples of professions in each category are given in Table 3. The respondents were classified into these categories on the basis of their answers to two open questions, the first asking what the job title of their main job was, the second asking what the respondents did in their main job.

Table 3. Classification of occupations and examples

Category	Example
Education	
Non-academic	High school teacher
Higher vocational education	Lector
University	Assistant professor
Research	
Junior	Postdoctoral researcher
Intermediate	Group leader (in research), assistant professor
Senior	Associate professor, full professor, senior scientist
Content specialist / consultant	
Consultant	Strategic consultant
Policy advisor	Policy advisor
Medical specialist	Cardiologist
Clinical fellow	Doctor in training to become a medical specialist
Medical specialist and clinical fellow	Neurologist also training in pathology*
Other health care	Clinical psychologist
Lawyers and other legal professionals	Lawyer
Other content specialist	Data analyst, technology specialist
Manager	
Research manager	Project manager of European projects
General manager	Technical project manager
Self-employed	Partner in start-up company
Other	Carpenter*

* Fictitious label to prevent identification of individuals.

One third of recent PhDs from Dutch universities was active in education, of which most were involved in university teaching (Table 4). Seven in ten were involved in research or experimental development according to the open answers. Hence, there is a discrepancy between the respondents' answers to multiple-choice questions that showed 88% were active in research and development, and their answers to an open question. This slight discrepancy is probably due to the fact that we asked respondents whether they did *any* R&D in the multiple-choice questions, whereas respondents may focus on their main job activities in answering an open question. Four in ten PhDs worked as content specialists, of which 30% as a medical specialist or as fellow training to become one. The group of content specialist also contains a considerable number of consultants, policy advisors and legal professionals. Furthermore, many PhDs in this group were working as "other" content specialists, e.g., as museum curator, clinical research associate or at a publisher. Finally, almost three in ten PhDs had a management job, of which most in research management.

Table 4. Job activities by gender (multiple main categories possible)

	Male	Female	Total
		%	
Education	29	38	33**
of which:			
Non-academic	2	2	2
Higher vocational	4	3	4
University	93	95	94
Research	71	71	71
of which:			
Junior	22	29	25
Intermediate	53	53	53
High	24	19	22
Content specialist	39	38	39
of which:			
Consultant	16	13	15
Policy advisor	4	7	5
Medical specialist	19	15	18
Clinical fellow	10	14	12
Both medical specialist and clinical fellow	0	< 1	< 1
Other health care	4	7	5
Lawyers and other legal professionals	4	1	3
Other content specialist	43	42	43
Management	25	31	28*
of which:			
Research management	62	71	67
General management	36	27	31
Self-employed	2	2	2
Other	< 1	< 1	< 1

*, **, and *** denote statistically significant difference of the independent variable at the 5, 1, and 0.1% levels, respectively.

Gender differences were only found in the main categories of education and management. Female PhDs were more likely to be involved in education, a finding also obtained in other studies (Dever et al, 2008, pp. 33-34; Fox & Stephan, 2001). However, females were underrepresented in the natural sciences, and engineering and technology, which have lower teaching loads than other fields (de Kok, de Jonge, & Tom, 2007). It may be that field of PhD is actually mediating the gender differences. Therefore, we again calculated what would have happened if the gender distribution would have been the same in all fields. Once more, gender differences became slightly smaller, which shows that the underrepresentation of females in some fields explains a part of the differences between female and male PhDs. However, females still had a statistically significantly higher chance of being involved in education.

In contrast to Dever et al. (2008), we found no gender difference in PhDs' involvement in research, and found that female PhDs were actually *more* likely to be involved in management. Here, overrepresentation or underrepresentation of women per field of PhD did not affect the gender differences.

Despite the lack of gender differences in research involvement, the fact that female PhDs were more likely to be involved in education may mean that in academia, female PhDs have a higher teaching load than male PhDs. Of the PhDs involved in research or teaching, we analyzed which share of PhDs was involved in both teaching and research, which share only in research and which share only in teaching. Female PhDs more often combined teaching and research (52% of females compared to 47% of males), whereas male PhDs were more often involved in research only (51% of males compared to 46% of females). However, these differences were small and not statistically significant.

For the PhDs with research position in their job description, we also analyzed the *level* of their position, i.e., junior, intermediate and senior. This analysis showed that male PhDs were more likely to have a senior researcher position, and female PhDs to have a junior position, but these differences were not statistically significant (Table 4).

8.3.3. Perception of career prospects

In the survey, respondents were asked to *rate* several aspects of *career prospects* in academia, non-academic research and outside research. Here, we will highlight two: long-term career perspectives and the availability of permanent positions. We hypothesized that gender influences the perception of these aspects, as would nationality, age and field of PhD. Nationality was measured as a dummy for high income OECD countries. This was done because researchers from lower income countries may decide to obtain a PhD in the Netherlands to increase their career opportunities in their home country. As such, PhDs from lower income countries may rate their career prospects with the home country in mind, and perceive them as better than they would rate career prospects in high-income countries. Indeed, Stephan et al. (2014) found that increasing career prospects in the home country is an important reason for researchers to do a PhD abroad.

We performed an ordinal logistic regression with the perception of career prospects (five-point Likert scale) as the dependent variable (Table 5). Gender influenced the perception of the availability of permanent positions in all three sectors: females rated this availability as worse than males. Furthermore, females rated the long-term career perspectives in academia as worse. An important explanatory factor was nationality: PhDs from high-income countries were more negative about both long-term career perspectives and the availability of permanent positions in academia and non-academic research.

Whereas field did not play a role in the perception of academic career prospects, it was the main influencer of the perception of prospects in non-academic research and outside research, with other factors playing no role, or a small one. Especially PhDs from the humanities tended to be more negative about career prospects in non-academic research and outside research, but those from the medical and health sciences, and from social sciences were also more negative. Although statistically significant effects were found, the Cox and Snell pseudo R^2 was small for all variables, which indicates that many other factors than the ones investigated explain the variance in perception.

8.3.4. Research performance

As described in our literature review, women tend to receive less research funding than men. To get an idea about whether there were gender differences in *research funding* among our respondents, we asked them whether they had received a grant for doing research. A total of four out of ten out of all PhDs had, with women actually being more likely to have received one: 45% of female PhDs had, compared to 37% of males ($p = 0.006$ in Pearson's $\chi 2$ test of independence). However, as indicated in the first part of the results section, a greater share of women than men were working in academia. Among only those currently working in academia, 54% of females had received a grant, compared to 48% of males, but this result was not statistically significant ($p = 0.138$). Clearly, female and male recent PhDs from Dutch universities are equally likely to obtain research funding.

One explanation given for gender gaps in academia is that women are less confident about their capabilities and careers than men (Baker, 2010). On the other hand, studies on the academic productivity of male and female academics also suggest the gender gap in publishing may be closing (van Arensbergen, 2014). Therefore, we asked the respondents how they would rate their *scientific oeuvre*. A slightly higher share of men indicated that their scientific oeuvre is "more than good enough" to build an academic career on (22% of males vs. 16% of females). However, a slightly higher share of women said their scientific oeuvre is "good enough" (56% of females vs. 52% of males). Furthermore, neither of these differences were statistically significant. Therefore, among recent PhDs in the Netherlands, women are as confident about their scientific oeuvre as their male counterparts.

Table 5. Effect of gender, nationality, age at survey and field of PhD on the perception of long-term career perspectives and the availability of permanent positions in academia, non-academic research and outside research (by ordinal regression)

	Academia		Non-academic research		Outside research	
Long-term career perspectives	B (S. E.)	p-value	B (S. E.)	p-value	B (S. E.)	p-value
Female	-0.36 (0.14)	0.012*	-0.30 (0.16)	0.057	-0.08 (0.16)	0.622
Nationality of high-income OECD country	-1.57 (0.24)	< 0.001***	-0.85 (0.26)	0.001**	0.15 (0.28)	0.598
Age at survey	0.03 (0.01)	0.024*	0.01 (0.01)	0.238	0.00 (0.01)	0.997
Field (ref. is engineering and technology)						
Medical and health sciences	0.04 (0.25)	0.867	-1.03 (0.27)	< 0.001***	-0.94 (0.27)	< 0.001***
Natural sciences	-0.27 (0.25)	0.293	-0.74 (0.27)	0.006**	-0.39 (0.28)	0.153
Social sciences	0.28 (0.28)	0.317	-1.31 (0.31)	< 0.001***	-0.92 (0.31)	0.003**
Humanities	-0.16 (0.30)	0.599	-2.25 (0.34)	< 0.001***	-1.68 (0.34)	< 0.001***
Number of observations	*684*		*592*		*567*	
Availability of permanent positions						
Female	-0.54 (0.15)	< 0.001***	-0.42 (0.16)	0.009**	-0.34 (0.16)	0.036*
Nationality of high-income OECD country	-1.42 (0.23)	< 0.001***	-0.52 (0.26)	0.043*	-0.08 (0.27)	< 0.001***
Age at survey	0.49 (0.12)	< 0.001***	0.00 (0.01)	0.834	-0.02 (0.01)	0.079
Field (ref. is engineering and technology)						
Medical and health sciences	-0.11 (0.25)	0.652	-0.84 (0.26)	0.001**	-1.24 (0.27)	< 0.001***
Natural sciences	-0.50 (0.26)	0.051	-0.48 (0.27)	0.074	-0.46 (0.28)	0.097
Social sciences	0.13 (0.29)	0.640	-1.31 (0.31)	< 0.001***	-1.11 (0.31)	< 0.001***
Humanities	-0.46 (0.31)	0.138	-1.67 (0.34)	< 0.001***	-1.66 (0.34)	< 0.001***
Number of observations	*687*		*567*		*549*	

8.4. Discussion and policy implications

When assessing gender differences in the employment situation, career perception and research performance of recent PhDs from Dutch universities, the most striking finding is that for most characteristics the differences between female and male PhDs are only small. They mainly pertain to sector of employment, type of contract and occupation, in the latter case only in involvement in teaching and management. By themselves, these differences are not very meaningful and the lack of real differences in these aspects is encouraging from the perspective of gender equality. However, taken together and combined with the large gender difference in part-time employment, they could lead to larger differences later in the career: "many mole hills together become a large mountain" (Maes, Gvozdanovic, Buitendijk, Rahm Hallberg, & Mantilleri, 2012). Previous studies have shown that small differences together lead to larger differences in later career stages, through cumulative disadvantage (Jacobs, 1996; Maes et al., 2012). Suggestively, female PhDs in our study were more negative about their career prospects than male PhDs. In the literature, gender disparities such as the ones found in our study, are partly ascribed to culture-specific national perception of femininity and masculinity in relation to science, work and family, as well as to a culture-specific masculinist model of science, including male-oriented organizational, social and cultures norms within the academic working environment (van den Brink & Benschop, 2012a; 2012b).

There already is a large gender difference before women and men even embark on a PhD, namely the choice of field of study. In most industrialized countries, women now make up over fifty per cent of all university students, but they are still underrepresented in the STEM fields, for example in Canada and the United States (Hango, 2013; NSF/NCSES, 2015). The Netherlands is no exception, with female students being overrepresented in education and social sciences, but heavily underrepresented in the natural sciences, and engineering and technology in 2013/'14 (Statistics Netherlands, 2015). Several explanations have been given for this phenomenon; Blickenstaff (2005) outlines nine, including but not limited to attitude and early experiences, curriculum design, teachers' attitude towards boys and girls, and the pressure to fulfill gender roles. Gender stereotypes with respect to science are still pervasive: science is associated with men, and this association is especially strong in the Netherlands (Miller, Eagly, & Linn, 2015). In the Netherlands, the gender differences at high school level seem to be decreasing though, with more female high school students now following a curriculum oriented towards the natural sciences and engineering (an increase from 20% in 2007/'08 to 38% in 2013/'14; Statistics Netherlands, 2014b). This suggests that, in time, the share of females among PhDs in the natural sciences and engineering may also increase, but that the share of females will still lag behind that of males for a considerable number of years.

The second large gender difference we found was in part-time employment, with female PhDs working part-time much more often than male PhDs. In itself this is not a surprising finding, as part-time employment is very common among women in the Netherlands, more so than in any other OECD country (OECD, 2012). An explanation for this phenomenon could be found in the fact that traditional motherhood ideology is still strong in the Netherlands (Portegijs, Cloïn, Ooms, & Eggink, 2006). In addition, part-time employment has become institutionalized, especially for women and even for high-skilled work, which enables such a large share of women to work part-time (Bosch, van Ours, & van der Klaauw, 2009). However, the fact that female PhDs work part-time more often (especially those with young children, and especially those working in the Netherlands) may hamper their career advancement in the long run, as the model of the ideal worker still includes full-time employment (Baker, 2010; van den Brink & Benschop, 2012a; Visser, 2002). Indeed, although differences in job level of PhDs in research were very small in our study, men were more likely to occupy a senior position. This may be why female PhDs are less positive about academic career prospects, despite being as confident about their scientific oeuvre as men.
In conclusion, there are only small gender differences in the job type, occupation, career perception and research performance of recent PhDs from Dutch universities. However, through accumulation these small differences and the large differences in field of study and part-time employment, can lead to more serious gender gaps in later career stages, both in academia and in other sectors of employment.

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8.6. References

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CHAPTER 9

Discussion

9.1. Introduction

In the introduction of this dissertation, we highlighted the increased attention to career conditions in science and observed that many identify a lack of career opportunities, long spells of employment on temporary contracts, and dependence on third party funding as problems that impair the attractiveness of science as a career. The figures on the composition of the academic workforce in, for example, the U.S. and Germany reviewed in this dissertation and elsewhere (e.g., Hill & Einaudi, 2010; Konsortium Bundesbericht Wissenschaftlicher Nachwuchs, 2013, p. 181; Schuster & Finkelstein, 2006, p. 46; VSNU, 2015a), point to an increasing share of junior staff and decreasing share of senior staff. In the U.S. especially, the number of postdoctoral researchers has increased spectacularly. This evokes questions such as why this development took place and whether it will continue,[1] what the relation is between the formal academic career structure and actual publication career spans, and whether changes in academic career structure and resulting changes in career opportunities and employment conditions have actually affected those in the academic workforce.

In this concluding chapter, the findings of this dissertation are summarized, put into perspective, its main strengths and limitations are listed, directions for future research are given, and policy recommendations formulated.

9.2. Main findings in perspective

The first research question identified in the introduction is:

1. What are the key topics discussed in *Science* and *Nature* editorials relating to academic career policy?

Chapter 2 answers this question through a description of the issues in career policy that are seen as most important according to *Science* and *Nature* editorials. In total, almost one in ten editorials in *Science* and *Nature* published 2000 – 2012 was on career policy. The six main clusters of issues identified are career conditions in science, the attractiveness of science as a career, merit-based career policies, the effect of research funding on careers, specific groups underrepresented in science (including women), and mobility of scientists. The editorial writers (distinguished scientists, high level policymakers and *Nature* editors) worry about the conditions for careers in science, which they characterize as uncertain and lacking in career prospects, especially when it comes to permanent positions.

[1] Very recent numbers on postdoctoral researchers in U.S. biomedical science tentatively point to a halt in the previous trend of ever-increasing numbers of postdocs (Garrison, Justement, & Gerbi, 2015).

This characterization is not new. Already in 1918 the famous sociologist Max Weber stated: *"[T]he career of the academic man in Germany is generally based upon plutocratic prerequisites. For it is extremely hazardous for a young scholar without funds to expose himself to the conditions of the academic career. He must be able to endure this condition for at least a number of years without knowing whether he will have the opportunity to move into a position which pays well enough for maintenance."* (Weber, 1918, p. 1).

Hence, the fact that academic careers can be considered as quantized and highly uncertain is not unique to current times.[2] Therefore, the second research question of this dissertation was:

2. Historically, how has the composition of academic positions changed in Germany and how has the span of publication careers of PhD recipients from the United States changed (both before and after the PhD)?

Chapter 3 constitutes the first assessment of developments in the academic career structure in Germany over such a long period of time (i.e., from the early 19th century until now). The chapter showed an increasing differentiation in academic positions, i.e., over time, more and more "lower" positions were added to the career system. The assessment also showed how important the professionalization of these positions was. In many cases, persons were already performing the job activities that belong to these lower positions, but these jobs were not recognized as proper positions and remunerated through a salary. Only with the literal professionalization of these positions they appeared in official statistics. Therefore, it is through professionalization that differentiation took place. Hence, one should be careful in inferring conclusions about the make-up of the academic career system, as only recognized and paid positions are reported on.

Furthermore, the growth of the whole academic workforce is correlated with the opportunities of higher (usually permanent) academic positions: when the growth rate is high, the opportunities for such positions increase, but when the growth rate slows down, the opportunities decrease. This is not the case for temporary positions; the opportunity to obtain such positions still increased despite the slowing down of the growth of the academic workforce. This relation between expansion and career opportunities has also been described in an almost forgotten paper by Ben-David and Zloczower (1961), but we are the first to empirically show this relation using post-1950 figures on academic positions. Thus, universities follow a basic economic principle: in economically prosperous times, there is a large demand for skilled employees. To attract these skilled employees in a tight labor market, many are

[2] Luckily for the author of this dissertation, and countless numbers of other women, there *have* been other developments through time: the fact that Weber only talks about the "academic man" is now an outmoded notion.

hired on permanent contracts and thus have large opportunities for career progression. However, when growth slows down, the demand falls and there may even be an oversupply of skilled employees. Universities respond by shifting to temporary employment. In addition, because so many higher, permanent positions have already been filled up, chances for career progression diminish for new entrants.

Therefore, in times of high growth a larger share of new entrants experience career progression than in times of low growth. If the distribution of talent is the same in in both periods, it follows that in slow growth periods, the average talent of the incumbents is lower than that of recent entrants promoted to a higher position. It must even be presumed that a substantial part of incumbents has less talent than a part of the recent entrants who are not promoted and leave academia. This necessarily implies that science does not employ the highest possible talent pool.

With a shift from senior to more junior positions in science, it would be expected that a smaller percentage of scientists have long publication careers. Surprisingly, it turns out that in the U.S., the span of publication careers has not changed very much in the majority of the studied fields, despite profound changes in the composition of the academic workforce since the 1950s (*chapter 4*). This implies that people are not "leaving" academia more often, but they stay in junior, temporary positions for a longer period of time. In contrast, pre-PhD publication careers became longer: whereas in the 1950s, most PhDs published their first article after the year of PhD, in the 2000s they published it several years before the year of PhD. The study in this chapter is the first to investigate the publication careers of such a large sample of doctorate recipients over such a long period of time. Furthermore, it is the first to empirically show that the year of first publication shifted in many fields. Finally, it is the first to empirically show that the span of post-PhD publication careers remained stable in many fields.

These findings show that changes in the composition of the academic workforce do not affect the length of publication careers by much. So is it possible after all to make employment conditions more sober with no consequence to the people in the system? This brings us to this dissertation's third main research question:

3. What are the effects of career prospects and employment conditions on early career researchers in the Netherlands?

This question was answered through two surveys, one among recent PhDs from five Dutch universities and one among PhD candidates at a Dutch university. The first sub-question answered, was:

a. How are career prospects in academia and other sectors perceived by recent PhDs from Dutch universities, and how is this perception related to their job choices?

Chapter 5 shows that recent PhDs rate career prospects in academia as much slimmer than in non-academic research and outside research, especially the availability of permanent positions. The perception of academic career prospects is related to actual sector of employment: PhDs outside academia are even more negative about academic career prospects than PhDs in academia. This association remains even when controlling for factors such as appealing job attributes and several personal characteristics. Whether PhDs find employment outside academia depends heavily on which job attributes they value, such as intellectual challenge, creativeness and contribution to society. For academia, this leads to a selection against certain types of PhDs, such as those who find contribution to society important. The fact that in the job choice of PhD students and graduates, preferences for certain job attributes play a large role, is confirmed by other studies (Balsmeier & Pellens, 2014; Bloch, Krogh Graversen, & Skovgaard Pedersen, 2015; Roach & Sauermann, 2010). Our study is the first to show conclusively that the perception of career prospects is indeed correlated with the actual sector of employment.

Our findings imply that the job choice of PhDs is dependent on personal preferences and labor market conditions. An interesting stream of future study would be to assess to which extent the personal preferences are shaped by socialization into academia during the PhD, and to which extent they are based on more stable preferences belonging to the individual itself (although this is a very difficult distinction to make, of course). Socialization has been described as a process in which prospective group members incorporate the norms and values of the group of people they would like to join (Austin, 2002). It has been described as a mechanism that "effectively isolates [graduate students] from competing vocational and intellectual interests and (…) [makes them] extremely dependent on [their] teachers" (Hagstrom, 1965, p. 9). As also discussed in section 1.4, socialization into academia may lead to the expectation of relatively poor career prospects in academia and long periods of temporary employment. Hence, the psychological contract between an early career researcher and employer may not include the expectation of job security. In psychological contract theory, a lack of job security would then not lead to a breach of contract and thus not lead to dissatisfaction or job exit either. The study presented in *chapter 5*, and many others (e.g., Cyranoski, Gilbert, Ledford, Nayar, & Yahia, 2011; Stanford et al., 2009; van der Weijden, Teelken, de Boer, & Drost, 2016), show that a majority of early career researchers see poor career prospects and employment conditions as a problem, but that job attributes such as degree of independence still attract them to academia. This shows that indeed, personal preferences (which may be caused in part by socialization into academia) function as a buffer to changes in labor market conditions – one that prevents early career researchers to search and find employment outside academia. Still, *chapter 5* also shows that if such a buffer is at play, it is stronger for some PhDs than for others. In fact, for some PhDs, the balance has swung to job exit from academia. This shows that, at least for these PhDs, the buffer did not prevent them from searching and finding employment outside academia. It is also likely that the forces of personal preferences and labor market conditions are not stable but dynamic over time, with negative factors playing a larger role over time and positive factors playing a smaller one: the "hangover" effect (Boswell, Shipp, Payne, & Culbertson, 2009; Lawler, Kuleck, Rhode, & Sorensen, 1975; Vroom & Deci, 1971). This means the buffer to the effect of labor market conditions becomes smaller over time.

In addition, the presence of such a buffer does not negate that changes in labor market and employment conditions have other effects on early career researchers, such as an effect of employment conditions on job satisfaction. Therefore, the second sub-question went into the effects of employment conditions on the job satisfaction of recent PhDs, and asked:

b. What is the effect of temporary employment on the job satisfaction and personal lives of recent PhDs from Dutch universities?

Theories relevant for this question are dual labor market theory and psychological contract theory. Dual labor market theory proposes that temporary employment negatively affects the job satisfaction and well-being of workers. Importantly, disparities between workers on temporary contracts and those on permanent contracts tend to persist according to this theory. However, it is also hypothesized that certain groups, such as the young and highly educated, are an exemption to this rule, as they can use temporary jobs as a stepping stone to permanent employment. An explanation could lie in the psychological contracts between these employees and their employer. If employees think they can use a temporary job to gain experience and use it as a stepping stone in their career, there is a balanced exchange between them and the employer. In this case, the psychological contract includes no expectation of permanent employment and the temporary employment does not affect job satisfaction. Taken together, temporary employment need not affect PhDs.

However, our study shows that temporary employment does have a negative influence on PhDs' job satisfaction – a strong negative influence on the satisfaction with employment conditions and a smaller one on the satisfaction with job content (*chapter 6*). Temporary employment also negatively affects the personal lives of PhDs. Thus, PhDs are not exempt from the negative effects of temporary employment. As our group of study included PhDs on various types of contracts (and also self-employed PhDs), and we had data on covariates such as sector of employment and job level, we were able to estimate the effect of temporary employment independently from these factors, something which other studies were unable to do (e.g., Bender & Heywood, 2006; Moguérou, 2002; van der Weijden et al., 2016).

An interesting phenomenon occurs with regards to sector of employment: on the one hand, academic jobs are much more likely to be temporary jobs, which negatively influence satisfaction with job content. On the other side of the balance, however, temporary jobs are more likely to be jobs at the level of educational attainment, which has a positive influence on satisfaction with job content. Non-academic jobs have the advantage that they are permanent jobs more often, but they also involve work below PhD level for a larger share of PhDs.

Other studies show that the adverse effect of temporary employment is not restricted to the employee but may also apply to scientific output. A majority of studies (usually in the private or service sector) find a positive influence of job satisfaction on productivity (e.g., Böckermann & Ilmakunnas, 2012; Schneider, Hanges, Smith, & Salvaggio, 2003). Furthermore, Smeenk (2007, pp. 47-86) showed that among European academics, employment security results in higher organizational commitment[3] and slightly higher job performance. Thus, the current HRM policy at (Dutch) universities could hurt the universities' performance, a conclusion also drawn by Thunnissen in her very recent dissertation on talent management in Dutch academia (2015, p. 183).

A more direct effect of employment conditions on early career researchers is shown in this dissertation's study of PhD candidates at a Dutch university. *Chapter 7* answered the sub-question:

c. What is the effect of appointment type on the availability of research infrastructure, work pressure, stress, and career attitudes of PhD candidates at a Dutch university?

The findings showed that externals are as satisfied with their PhD experience as internals, but they feel disadvantaged with respect to material infrastructure: they report less access to office

[3] However, this effect only occurs in environments with low managerialism (Smeenk, 2007, pp. 47-66).

facilities, less funding for research and a much lower personal income. Thus, (differences in) employment conditions affect early career researchers in the way they are able to conduct their research. PhD candidates employed by the university had much more access to material research infrastructure than non-employed PhD candidates, although both groups were essentially working towards the same goal: a doctoral dissertation. This compromises organizational justice; to be more specific, distributive justice ("who gets what relative to one's input"), which has been shown to affect job satisfaction, organizational commitment and organizational citizenship behavior (although other forms of organizational justice are stronger influencers of the latter two; Colquitt, Conlon, Wesson, Porter, & Ng, 2001). Hence, the employment conditions of PhD candidates can influence the material infrastructure available to PhD candidates if no explicit policy is implemented to prevent inequalities.

Finally, *chapter 8* looked at the role of gender in post-PhD careers. Much of the research on gender and careers in science is on academia only, whereas a large share of the scientific workforce works in other sectors. Therefore, chapter 8 answers the sub-question:

d. What is the effect of gender on the type of employment, occupation, career perception and research performance of recent PhDs from Dutch universities?

The assessed outcomes included sector of employment, job level, employment contract, perception of career prospects, the reception of research grants, the perception of the own scientific oeuvre, and occupation. To determine occupation, we introduced a novel, fine-grained classification scheme for classifying PhDs' jobs.

Gender is a factor that moderately influences both the perception of career prospects and temporary employment and thus, has a small, mediating role in the effect of employment conditions on early career researchers. There also are other gender differences: female PhDs go into academic research more often than male PhDs, and female PhDs are more involved in teaching. Much larger gender differences were found in the field of study: women are underrepresented among recent PhDs in engineering and the natural sciences. This gender difference already occurred earlier in the educational career, namely in high school (Statistics Netherlands, 2015). Although it is far too soon to draw definitive conclusions, this gap may be closing, as more female high school students are now following a curriculum oriented towards the natural sciences and engineering (Statistics Netherlands, 2014). Another large gender difference was found in part-time employment: female PhDs work part-time much more often than their male counterparts, especially when working in the Netherlands or having young children. At later stages in the career, this may hold back female PhDs in the development of their careers, in combination with other small gender differences through cumulative disadvantage (Jacobs, 1996). To put it more bluntly: many mole hills together could become a large mountain (Maes, Gvozdanovic, Buitendijk, Rahm Hallberg, & Mantilleri, 2012). However, in most aspects of early post-PhD careers no or only small gender differences were found, which may be a sign that there will be gender equality also in later career stages.

9.3. Strengths and limitations of the dissertation

This final, nuanced, conclusion on the role of gender in post-PhD careers brings us to the main strength of this dissertation: its separation of hear-say from hard evidence through critical empirical testing, also when evaluating the hypotheses proposed in the dissertation itself. The scientific literature on academic positions often mentions the increasing precariousness of academic careers (see for example *chapter 7* in this dissertation). *Chapter 3* confirms this image when comparing career opportunities in 2010 to those in 1970, but also shows that employment conditions were arguably better in 2010 than before 1950. *Chapter 4* tested the superficially obvious presumption that fewer opportunities to obtain a tenured or tenure-track position at a U.S. university and an increasing share of postdoctoral positions would lead to shorter publication careers, and proved this presumption to be wrong. Nothing of the sort was observed; publication career spans appear to have remained quite stable in most fields studied, or became even longer. Similar nuanced pictures were painted on the effect of career prospects and employment conditions (*chapters 5* to *7*). Our studies found an effect of poor career prospects on job choice, of temporary employment on job satisfaction and of non-employee status of PhD candidates on the availability of material research infrastructure. At the same time, they also explicitly described that job characteristics such as intellectual challenge and independence tend to be more important to early career researchers than employment conditions, and non-employee status of PhD candidates does not affect PhD supervision.

Another strength of this dissertation is that it empirically examines several aspects of the academic career system: key issues, historical development, and its effect on early career researchers. It does so using a variety of methods: text mapping, analysis of official statistics, bibliometric analysis and surveys among large numbers of respondents. In order to answer the dissertation's three main research questions using an appropriate subject of study *and* to take advantage of available data and data collection opportunities, different samples and datasets were used. For the key issues, the sample consisted of *Nature* and *Science* editorials in order to map the key topics in academic career policy as identified by a variety of distinguished scientists, high level policymakers and *Nature* editors (*chapter 2*). To study historical developments in academic positions, the composition of academic staff in Germany was chosen, as the research university originated in that country (*chapter 3*). To study historical developments in publication careers of doctorate recipients from the 1950s, the United States was chosen as that country became the leader in science after the Second World War and good data are available for that country – the ProQuest database constitutes the highest quality database on doctoral dissertations (*chapter 4*). To study the effect of the academic career system on early career researchers, the Netherlands was chosen as it is a representative country of good quality (though not necessarily elite) science. This makes the Netherlands a suitable country to study the effects of career prospects and employment conditions for PhD graduates with good quality degrees, who are important in shaping the knowledge economy (OECD, 1996; *chapters 5*, *6* and *8*). The effect of PhD appointment type naturally had to be studied in a sample of PhD candidates, still another group of researchers (*chapter 7*).

Of course, this choice of appropriate samples and datasets by research question implies that the answer to one research question is not directly generalizable to the sample used in another research question. For example, the developments in the composition of academic staff in Germany showed a differentiation of academic positions and strongly implied decreased opportunities to obtain a permanent position due to a slowdown of higher education expansion. This dissertation did not look into these developments in the United States and the Netherlands, which means the findings from Germany are not directly translatable to these countries. However, it is likely that a similar development occurred in the U.S. and the Netherlands, as the literature on academic positions in the U.S. (as presented in *chapter 4*) sketches a very similar picture of differentiation of academic positions, and data from the Netherlands show an increase in temporary positions over the past decades (VSNU, 2015b). Based on the literature on U.S. academic positions, we concluded that a differentiation of academic positions did not lead to shorter publication careers of U.S. doctorate recipients. The findings on the publication careers of U.S. doctorate recipients themselves are less readily generalizable to Germany and the Netherlands; this topic is an excellent candidate for further inquiry. Finally, the effects of career prospects and employment conditions are, in a way, very dependent on the national context, as the exact career prospects and employment conditions vary by country. A case in point here is that in most countries, PhD candidates are formally treated as students, but in the Netherlands treated as employees if they are appointed by the university. Still, in another way, the effects of career prospects and employment conditions appear to persist globally – which is easily illustrated by the *Nature* and *Science* editorials studied in *chapter 2*.

Another characteristic of this study is that its sphere of study is large – by design, the dissertation does not focus only on top researchers, research groups or universities. While *Nature* and *Science* editorials do focus somewhat on science in the developed world (especially *Science*, which is the flagship journal of the American Society for the Advancement of Science), a large minority of editorials also explores academic careers in other parts of the world. This means that the identification of key issues in policy regarding the scientific workforce is also based on this wide scope (*chapter 2*). Similarly, the chapter on developments in academic positions focused on all German universities (*chapter 3*) and publication career spans focused on all research doctorate recipients from U.S. institutions (although five specific fields were chosen and the analysis was based on a sample of doctorate recipients with rare names; *chapter 4*). The sample of the PhD graduates survey included all PhDs who obtained a PhD from one of five Dutch universities in a defined period of time (*chapters 5*, *6* to *8*), and all PhD candidates at Leiden University could have participated in the PhD candidate survey (*chapter 7*). Since differences in policies and scientific achievement between Dutch universities are small, much smaller than between, for example, leading U.S. universities and the U.S. average, our findings are representative for the Netherlands as a whole and probably also for a group of countries and groups of university worldwide – those where good quality but not necessarily top research is conducted. As talent distribution in science is very skewed (De Solla Price, 1963, p .41), it might be interesting to study whether similar results hold true for elite researchers in different countries and universities. It is conceivable that elite early career researchers respond differently to perceived career prospects and employment conditions – perhaps they have a stronger "taste for science" (Roach & Sauermann, 2010) and are therefore even more sensitive to degree of independence and less sensitive to unattractive employment conditions and career prospects than the PhDs in our sample. This would merely mean that they are in one part of the spectrum our sample revealed, not that they are outside that spectrum, though. However, this does not quite seem to be the case, as postdoctoral researchers at Harvard University, too, see a lack of career prospects in academia as a problem (Polka & Krukenberg, 2014). Anyway, as a strong knowledge economy requires a broad base of scientifically educated persons (OECD, 1996), it is the situation of representative early career researchers that is essential, not just elite researchers.

A limitation of the studies in this dissertation into the effect of career prospects and employment conditions on early career researchers is that they rely on the reports on these effects by researchers themselves, either directly through analyzing which issues they write about (the study of editorials and some analyses from the survey-based studies) or indirectly by analyzing the relationship between different answers to survey questions. Through multiple mechanisms, it is possible that surveys do not accurately measure the value of a variable the researcher is interested in (de Leeuw, Hox, & Dillman, 2008). Other possible study designs include choice experiments of several job characteristics, or conducting open-ended interviews with early career researchers. However, such study designs also have drawbacks. Choice experiments do not measure actual employment outcomes and interviews provide more background details to the job choice of individuals, but are not suited to obtain data on many individuals. Consequently, as always in research into a relatively new subject, the inevitable conclusion is that further research is needed.

9.4. Directions for future research

The further research should address some of the many questions raised by the work reported in this dissertation. First, there is an issue this dissertation has only scratched the surface of: the increasing importance of project based, competitive funding. Public R&D funds are distributed in roughly two manners: as block grants to whole universities or research institutes (Dutch: *eerste geldstroom*) or as project based grants to individual research groups or scientists, through intermediary agencies (Dutch: *tweede geldstroom*; Lepori et al., 2007). The last four decades have seen a shift from block funding to project based funding (Lepori et al., 2007; Kreckel, Burkhardt, Lenhardt, Pasternack, & Stock, 2008, pp. 62-64). In 2005, approximately one third of all research associates at German universities were funded through project based funding (Kreckel et al., 2008, p. 63). In the Netherlands, the increase of project based funding is often linked to the increase in non-permanent positions in academia (Jongsma, 2015; "Kwaliteit onderwijs en onderzoek lijdt onder de flexwerkende wetenschapper", 2013; "Tijdelijk geld is onzeker geld", 2015). This relationship is also mentioned by Kreckel and colleagues (2008, p. 64). The question is whether this is indeed the case. Although this relationship may seem straightforward, the increase in project based funding coincided[4] with, for example, increased managerialism in higher education and increased reliance on new public management with its preference for indicator based, process oriented decision making over qualitative, content based leadership (Teelken, 2012). This makes it difficult to determine a causal relationship between mode of funding and career structure.

A second, new, research question is whether an earlier selection of academic talent for uncertainty reducing tenure tracks and permanent positions is possible. On the basis of which factors could this selection take place? Relatively straightforward measures would be the productivity and citation impact of researchers. Several studies into the predictive validity of past productivity and impact have been conducted. For example, Dennis (1956) found that past productivity is the best predictor of future scientific productivity. Cole and Cole (1967) found that scientists with a large number of citations to early work continue to be highly

[4] Of course, it is likely that there is not a mere coincidence, but rather, that managerialism and new public management may have links to both the reliance on project funding and with employment conditions.

productive. Similarly, Nederhof and van Raan (1987; 1989) found that the productivity and citation impact of physics and chemistry doctorates was higher for those who received their PhD degree with distinction than for those who did not receive their degree with distinction. This implies that early differences in productivity and citation impact occur. However, the authors also found that difference in productivity and impact became smaller after the PhD, which calls into question the notion that early productivity and citation impact are predictors of productivity and citation impact in the later career. In addition, in this example, the *mean* number of published papers and citations differed for the two groups. However, if there is large variance in the numbers of publications and citations – which is to be expected due to the skewed distribution of talent (De Solla Price, 1963, p. 41) – the predictive validity could still be low. Indeed, a recent study on the predictive validity of early publications by mathematicians showed that whereas early productivity is correlated with future publication rate, the predictive validity is far from perfect (Lindahl & Danell, 2015). If these findings also hold true for young scientists in other fields, earlier job security based on performance during the PhD and a short postdoctoral period would be possible, but there should remain opportunities for "slow starters" to prove themselves gradually.

A third research question involves the study population. When assessing the effect of career structure on researchers, the studies in this dissertation have focused on early career researchers, i.e., PhD candidates and recent PhD graduates. This leaves open the question what the effect of quantization is on researchers in a later stage of their careers. And what about prospective entrants into academic careers: bachelor and master students? Do they let employment conditions in academia influence whether they go into research, are they ignorant about employment conditions, or do they just not care about them? We already noted that although the effects of quantization of academic careers were only determined within a group of PhD candidates at a Dutch university and PhD graduates of Dutch universities in this dissertation, it is likely that they are representative of a much larger population of early career researchers. This is borne out by the fact that the quantization of academic careers appears to be quite a global phenomenon (as evidenced by the analysis of *Nature* and *Science* editorials; *chapter 2*). An important and interesting follow-up line of research similar to ours could be to verify whether our results are indeed representative of a larger population of early career researchers.

A fourth and final research question is whether science itself is affected by the structure of academic careers and employment conditions. It does not seem unreasonable to suggest that the trend towards quantization and less independence must have had an impact on the freedom and willingness to do "risky" research and therefore on the opportunity to achieve breakthroughs at an early time in the research career. In this respect, it is suggestive that the age at which the breakthroughs were achieved that eventually led to a Nobel Prize increased substantially during the last century (Jones, 2010). Accordingly, it is clearly worthwhile to do follow-up research into, for example, the time between PhD and the most cited paper to assess whether the length of this period has increased over the past decades.

9.5. Policy implications and recommendations

Three main policy recommendations can be inferred from the studies in this dissertation. The first concerns job security, the second differentiation in career tracks for PhD graduates and the third is aimed at the incorporation of career policy in the steering of science in general.

The first recommendation is to provide more job security earlier in an academic career. The importance that early career academics attach to career prospects and job security in academia are shown in the studies in this dissertation. These studies imply an underinvestment employment relationship between the early career academics and their employers, similar to the relationship described by Thunnissen (2015, pp. 182-183) in her work on early career academics at Dutch universities. Quite possibly, the early career academics in both this dissertation and in Thunnissen's have experienced a breach of the psychological contract between them and their employers. Such breaches do not necessarily lead to exit by the employee – an easy to observe negative consequence – but can, as noted before, instead lead to silence, the voicing of complaints, or neglect (Rousseau, 1995, pp. 136-138). The latter consequences are undesirable for the organization as well. By giving job security earlier in academic careers, especially to the most promising young researchers, these negative consequences could be counteracted, provided sufficient "slow starters" are still given the opportunity to prove themselves later if the predictive validity of early performance is good, but not precisely accurate.

A reason sometimes given for the many temporary contracts in academia, is the increase in project based funding. However, if a research group or department has a steady number of PhD candidates and postdoctoral researchers, the *group*'s funding does not lack stability.[5] Some of these researchers could be hired on a permanent contract instead of being replaced every two to four years. Often, this is allowed by the rules of funding instruments. Thus, the guidelines of one of the most important funding instruments in the Netherlands, the *Vernieuwingsimpuls*, do not explicitly prohibit the funding of salary costs of permanently appointed employees as project researchers (NWO, 2015). Hence, if the funding in a research

[5] This feeling has recently begun to find political expression ("PvdA boos over tijdelijke contracten aan universiteiten", 2015)

group is relatively stable, universities could be less hesitant in employing researchers in such a group on a permanent contract. However, such a policy change does imply earlier selection of individuals. Whether this is possible, is a question for future research (see section 9.4).

The second recommendation is to differentiate career tracks for PhD graduates, both in academia and in other sectors. Formal career tracks in academia are heavily based on a narrow view of scientific talent (van Arensbergen, Hessels, & van der Meulen, 2013, p. 78). A few decades ago, studies already described how tenure and merit pay decisions are based more on accomplishments in research than in teaching or service (Fairweather, 1995; Kasten, 1984). This dissertation showed that this also attracts a specific type of person, i.e., one who values intellectual challenge and independence (*chapter 5*). However, other types of persons, such as the ones who value contribution to society, work outside academia more often. To attract other types of people, career tracks should be diversified and reward a wider range of skills. There has already been a development towards teaching-oriented careers ("Onderwijscarrière in zicht", 2014) and careers oriented on the societal impact of research (de Jong, 2015). Related to this is the recommendation to increase the employability of PhDs outside academia. Approximately thirty per cent of PhD graduates from Dutch universities work in higher education (Auriol, Misu & Freeman, 2013, p. 19). This means that a majority of PhDs find employment outside academia. Outside academia, a relatively large share of PhDs indicate they work at bachelor or master level, not at PhD level. Such a lower job level decreases job satisfaction. The fact that such a large share of recent PhDs work below their level of educational attainment implies either an excess supply of PhDs or a mismatch between the non-academic job market and PhDs' skills and experience. To decrease the mismatch, first of all, universities should market the qualities of their PhDs to non-academic employers better. Second, PhD candidates themselves should invest more in non-research oriented skills. Indeed, a preliminary analysis from the same survey that *chapters 5* to *7* are based on, shows that recent PhDs feel they developed skills such as analytical thinking and writing skills during their PhD sufficiently, but that they lacked the development of social, teamwork and management skills. Similar results were obtained for PhDs from Flemish universities (Boosten, Vandevelde, Derycke, te Kaat, & Van Rossem, 2014).

The title of this dissertation introduces the term "quantized careers": today, people at the start of a research career face a long string of disjointed temporary jobs and an extended period of uncertainty about their immediate and long-term future. This affects their choices and well-being, subtly more so if they are female, to the detriment of science and its societal impact. Thus, the third and final policy recommendation is one to national science authorities. These authorities should give priority to career policy in the steering of science. A shift to a more "neoclassical" system with greater smoothness, coherence and predictability of individual careers is duly needed.

9.6. References

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APPENDICES

Nederlandse samenvatting

Dankwoord

Curriculum Vitae

List of publications

Appendices

Nederlandse samenvatting

Het hedendaagse loopbaansysteem in de wetenschap wordt gekenmerkt door een gebrek aan loopbaanmogelijkheden, lange periodes van korte contracten en afhankelijkheid van financiering door derden. Dit proefschrift heeft onderzocht 1) welke vraagstukken in academische loopbanen gesignaleerd worden door vooraanstaande wetenschappers en beleidsmakers in het wetenschapsbeleid, 2) hoe het wetenschappelijke loopbaansysteem zich in de loop van de tijd heeft ontwikkeld in Duitsland en de Verenigde Staten, en 3) wat de effecten zijn van loopbaanperspectieven en arbeidsvoorwaarden op onderzoekers aan het begin van hun loopbaan (zie **hoofdstuk 1**).

Het beleidsveld dat zich bezighoudt met academische loopbanen is groot en omvat een grote diversiteit aan onderwerpen. Daarom is in het eerste deel van dit proefschrift het veld van loopbaanbeleid in de wetenschap in kaart gebracht en de vraag gesteld welke vraagstukken in het loopbaanbeleid de meest belangrijke en urgente zijn (eerste onderzoeksvraag). **Hoofdstuk 2** beantwoordt deze vraag door te beschrijven welke vraagstukken in loopbaanbeleid de hoofdredactionele commentaren in *Nature* en *Science* het belangrijkst vinden. In totaal ging tussen 2000 en 2012 bijna een op de tien hoofdredactionele commentaren in *Science* en *Nature* over loopbaanbeleid. De zes hoofdclusters van vraagstukken binnen loopbaanbeleid volgens *Nature* en *Science* zijn arbeidsvoorwaarden in de wetenschap, de aantrekkelijkheid van wetenschap als beroep, bevorderingsbeleid op basis van prestaties, het effect van onderzoeksfinanciering op loopbanen, ondergerepresenteerde groepen in de wetenschap en de mobiliteit van wetenschappers.

De overige hoofdstukken in dit proefschrift gaan verder in op de eerste twee kwesties: arbeidsvoorwaarden in de wetenschap en de aantrekkelijkheid van wetenschap als beroep. De analyse van de hoofdredactionele commentaren en andere beschikbare gegevens over loopbaanperspectieven in de wetenschap schetsen een beeld van verslechterde loopbaanperspectieven en meer tijdelijke aanstellingen. Aangezien een grondige historische analyse ontbrak in de wetenschappelijke literatuur, gaat de tweede onderzoeksvraag in op de ontwikkeling van wetenschappelijke loopbaansystemen in Duitsland en de Verenigde Staten, twee landen die koploper zijn geweest op het gebied van wetenschap in de 19^{e}, 20^{e} en (begin) 21^{e} eeuw. **Hoofdstuk 3** beschrijft de ontwikkeling van de structuur van academische loopbanen in Duitsland van de 19^{e} eeuw tot nu. Het laat zien dat er zowel differentiatie van wetenschappelijke posities als professionalisering van die posities heeft plaatsgevonden. De expansie en democratisering van hoger onderwijs lijken een grote rol hebben gespeeld in de differentiatie en professionalisering van de academische loopbaan. Daarnaast laat het hoofdstuk zien dat de mogelijkheden voor gepromoveerden een tijdelijke, juniorpositie aan een universiteit te verwerven alleen maar zijn toegenomen sinds de jaren vijftig, maar dat de mogelijkheden een hogere, seniorpositie te verwerven zijn afgenomen sinds de jaren tachtig. Het is aannemelijk dat dit komt doordat de groei van het hoger onderwijs is afgenomen sinds de jaren tachtig.

Er zijn dus grote veranderingen in de samenstelling van het wetenschappelijk personeel geweest. Maar wat hebben deze veranderingen betekend voor de publicatieloopbanen van wetenschappers? De bevindingen uit hoofdstuk 3 suggereren dat vaste banen zijn vervangen door korte contracten, en dat slechts een klein gedeelte van onderzoekers met zo'n kort contract een vaste baan zal krijgen. Als dat zo is, is de verwachting dat de periode waarin wetenschappers hun werk publiceren ook korter is geworden. Om dit te onderzoeken, beschrijft **hoofdstuk 4** trends in de lengte van publicatieloopbanen van gepromoveerden van universiteiten in de Verenigde Staten vanaf de jaren vijftig tot nu, in een vijftal velden. Dit is gerealiseerd door de namen van een deelverzameling gepromoveerden (degenen met zeldzame namen) in de astrofysica, scheikunde, economie, genetica en psychologie in de dissertatiedatabase *ProQuest* te koppelen aan de *Web of Science*-database van wetenschappelijke publicaties. Verrassend genoeg bleek dat in de meeste onderzochte disciplines de lengte van publicatieloopbanen na de promotie in de loop van de tijd niet erg veranderd is, ondanks de grote veranderingen in de samenstelling van het wetenschappelijk personeel en de arbeidsvoorwaarden. Daarentegen bleek dat de publicatieloopbanen *voor* de promotie langer zijn geworden: in de jaren vijftig publiceerden de meeste gepromoveerden hun eerste artikel gemiddeld in het jaar van hun promotie, terwijl gepromoveerden uit de periode 2000-2010 hun eerste artikel enkele jaren voor de promotie publiceerden.

De groei van het aandeel van tijdelijke banen impliceert dat loopbaanperspectieven en arbeidsvoorwaarden in de wetenschap zijn verslechterd. Dit leidde tot de derde onderzoeksvraag van dit proefschrift: welke effecten hebben deze verslechterde loopbaanperspectieven en arbeidsvoorwaarden gehad op onderzoekers aan het begin van hun loopbaan? **Hoofdstuk 5** analyseert de perceptie van loopbaanperspectieven binnen de wetenschap, het niet-universitaire onderzoek en buiten het onderzoek van recent gepromoveerden van vijf Nederlandse universiteiten. Ook wordt onderzocht in hoeverre deze perceptie samenhangt met de sector waarin de gepromoveerden daadwerkelijk werken. Deze analyse laat zien dat recent gepromoveerden de loopbaanperspectieven binnen de wetenschap lager aanslaan dan die in het niet-universitaire onderzoek en buiten het onderzoek, vooral de beschikbaarheid van vaste banen. De baankeuze van de recent gepromoveerden hangt samen met hun inschatting van de loopbaanperspectieven binnen de wetenschap: gepromoveerden buiten de wetenschap zijn nog negatiever over de perspectieven binnen de wetenschap dan gepromoveerden die in de wetenschap werken. Deze samenhang blijft aanwezig ook als is gecorrigeerd voor andere factoren, zoals verscheidene baaneigenschappen en persoonlijke karakteristieken. Of gepromoveerden buiten de wetenschap gaan werken, hangt af van welke eigenschappen in een baan ze belangrijk vinden, zoals intellectuele uitdaging, creativiteit en bijdrage aan de maatschappij. Voor de wetenschap betekent dit dat bepaalde typen gepromoveerden worden uitgeselecteerd, zoals zij die hun bijdrage aan de maatschappij belangrijk vinden – zij werken vaker *buiten* de wetenschap.

Deze bevindingen bevestigen het beeld dat de veelheid van tijdelijke banen in academische loopbanen als onaantrekkelijk wordt gezien. **Hoofdstuk 6** onderzoekt rechtstreeks wat het effect van tijdelijke contracten op de tevredenheid met de baan en het privéleven van recent gepromoveerden is. Tijdelijke banen komen al geruime tijd veel voor in de wetenschap, maar worden ook in andere sectoren steeds gebruikelijker. Volgens de duale arbeidsmarkttheorie zijn tijdelijke banen "bad jobs", die niet alleen inferieur zijn aan vaste banen qua arbeidsvoorwaarden, maar ook qua inhoud van de baan. Dit hoeft echter niet te gelden voor specifieke groepen, zoals jonge werknemers en hoogopgeleiden. Aangezien gepromoveerden zowel hoogopgeleid als (vaak) jong zijn, zouden zij zo'n uitzonderingsgroep kunnen vormen. Hoofdstuk 6 laat evenwel zien dat dit niet het geval is: tijdelijke contracten hebben een negatieve invloed op de tevredenheid met de baan. Er is vooral een grote invloed op de tevredenheid met arbeidsvoorwaarden, maar ook een invloed, zij het iets minder groot, op de tevredenheid met de inhoud van de baan. Hier doet zich een interessant fenomeen voor: aan de ene kant zijn banen in de wetenschap vaker tijdelijk, wat een negatieve invloed heeft op de tevredenheid met de baaninhoud. Aan de andere kant zijn banen in de wetenschap ook vaker banen op doctorsniveau, wat een positieve invloed op deze tevredenheid heeft. Buiten de wetenschap hebben gepromoveerden vaker een vast dienstverband, maar hebben ze ook een grotere kans dat het werk op bachelor- of masterniveau is, dus onder doctorsniveau. Ten slotte laat dit hoofdstuk zien dat tijdelijke contracten een negatief effect hebben op het privéleven van gepromoveerden.

Hoofdstuk 7 laat zien wat het effect van de aanstellingsstatus op de tevredenheid van promovendi is. In veel landen worden promovendi gezien als studenten, maar in Nederland heeft ongeveer de helft van de promovendi een aanstelling als werknemer bij de universiteit. De andere helft van de promovendi heeft echter geen aanstelling als werknemer. Dit werpt de vraag op wat het effect is van deze verschillen in aanstellingsstatus op de tevredenheid met het promotietraject. Op basis van een enquête onder promovendi van de Universiteit Leiden laat hoofdstuk 7 zien dat externe promovendi (niet-werknemers) even tevreden waren met de immateriële kant van hun promotietraject als interne promovendi. Ze waren echter achtergesteld qua materiële infrastructuur: ze hadden minder toegang tot werkplekken en andere kantoorfaciliteiten, minder geld beschikbaar voor onderzoek en een veel lager inkomen. Arbeidsvoorwaarden, en vooral ongelijkheid daarin, hebben dus een negatieve invloed op hoe onderzoekers aan het begin van hun loopbaan onderzoek kunnen uitvoeren.

Hoofdstuk 8 kijkt naar de rol van gender in de loopbanen van recent gepromoveerden. Loopbaanaspecten waarnaar is gekeken zijn baankarakteristieken, beroepen, perceptie van loopbaanperspectieven en prestaties op het gebied van onderzoek. Om de beroepen van gepromoveerden goed in te kunnen delen, is een nieuw, fijnmazig classificatieschema ontwikkeld. In veel aspecten waren de genderverschillen klein, zoals sector, beroep, type contract (hoewel vrouwen iets vaker een tijdelijk contract hadden), perceptie van loopbaanperspectieven, perceptie van het eigen wetenschappelijk oeuvre en het succesvol aanvragen van onderzoekssubsidies. Grote verschillen waren er echter in de wetenschappelijke discipline waarin het promotieonderzoek was uitgevoerd en in de deeltijdfactor. Vrouwen waren in sterke mate ondergerepresenteerd in de technische en natuurwetenschappen. Vrouwen werkten ook veel vaker in deeltijd (een derde van de vrouwelijke gepromoveerden ten opzichte van een tiende van de mannelijke gepromoveerden). Dit percentage was vooral hoog onder vrouwen met jonge kinderen. Aangezien het ideaalplaatje van een wetenschapper nog steeds voltijd werken behelst, kan hierdoor de loopbaanontwikkeling van vrouwen geremd worden. Op zichzelf betekenen de kleine genderverschillen die gevonden zijn niet veel. Bij elkaar en in combinatie met grote genderverschillen in discipline en deeltijdwerk, kunnen ze echter leiden tot grote genderongelijkheid later in de loopbaan.

Ten slotte zet **hoofdstuk 9** de bevindingen uit de empirische hoofdstukken in perspectief en worden de sterktes en zwaktes van het proefschrift bediscussieerd. Ook worden in dit hoofdstuk enkele beleidsaanbevelingen ter verbetering van het loopbaanbeleid in de wetenschap gegeven: eerder in de loopbaan baanzekerheid geven aan universitaire onderzoekers, differentiatie van loopbaanpaden voor gepromoveerden, zowel binnen als buiten de wetenschap en prioriteit geven aan loopbaanbeleid binnen universiteiten in het nationale wetenschapsbeleid.

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Curriculum Vitae

Cathelijn Waaijer werd op 21 juli 1986 geboren in Delft, tijdens de beklimming van de Col de la Croix de Fer (zoals haar vader, een groot wielerliefhebber, haar daarna vaak verteld heeft). In 2004 behaalde ze haar gymnasiumdiploma (profiel: Natuur & Gezondheid) aan het Erasmiaans Gymnasium in Rotterdam. Van 2004 tot 2010 studeerde ze Biomedische Wetenschappen aan de Universiteit Leiden. Tijdens haar studie is Cathelijn lid geweest van de jaarvertegenwoordiging van de master Biomedische Wetenschappen en van de symposiumcommissie, die het jaarlijkse BW-symposium organiseerde. Daarnaast heeft ze deelgenomen aan een uitwisselingsprogramma met het Karolinska Institutet in Stockholm en heeft ze een onderzoeksstage gelopen in de groep van dr. Sally Stringer aan de University of Manchester in het Verenigd Koninkrijk. Haar afstudeeronderzoek voerde uit bij het Centrum voor Wetenschaps- en Technologiestudies onder leiding van prof. dr. Cornelis van Bochove. Hier bracht zij de hoofdredactionele commentaren van *Science* en *Nature* in kaart. Op basis van dit onderzoek publiceerde ze haar eerste artikel in een wetenschappelijk tijdschrift: een kort stukje in *Nature*. In 2010 begon ze aan een promotieonderzoek bij de afdeling Pathologie van het Leids Universitair Medisch Centrum, maar na minder dan twee jaar heeft ze dit onderzoek stopgezet omdat haar hart meer lag bij onderzoek naar hoger onderwijs- en wetenschapsbeleid. In januari 2012 begon Cathelijn met haar promotieonderzoek bij het CWTS, onder supervisie van prof. dr. Cornelis van Bochove en prof. dr. Simone Buitendijk. Voor het onderzoeksvoorstel van haar promotieonderzoek heeft ze de *Eugene Garfield Doctoral Dissertation Award* van de *International Society for Scientometrics and Informetrics* (ISSI) ontvangen. Tijdens haar promotieonderzoek is Cathelijn bestuurslid externe zaken geweest van het Leids Promovendi Overleg (LEO) en algemeen bestuurslid van het Promovendi Netwerk Nederland (PNN, portefeuille Aanstellingen). Van 1 februari tot 1 juli 2016 is zij werkzaam geweest bij de afdeling Bestuurlijke Informatie van het Bestuursbureau van de Universiteit Leiden. Vanaf 1 mei 2016 werkt ze als postdoctoraal onderzoeker bij het Onderwijs Expertise Centrum van het LUMC om daar onderzoek te doen naar de wetenschappelijke vorming van de wetenschappers van de toekomst: (bio)medische studenten.

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Appendices

Appendix 1 (supplementary information to chapter 2)

Table S1. Terms used for selection of editorials

Used for selection editorials
Career
Tenure
Mobility
PhD system
Recruitment
Graduate school
Minority scientist
Woman scientist
Women scientists
Female scientist
Academic job
Junior researcher
Senior scientist
Senior researcher
Postgraduate training
Minorities
Did not result in additionally selected editorials
Junior scientist
Minority researcher
Female researcher

Table S2. Sensitivity analysis (number of editorials not in selection when omitted as % of total number editorials per category)

Term used for selection	Academic career as main subject	Academic career as one of several subjects	Academic career not a subject
Career	36 (31.9%)	37 (48.1%)	72 (52.9%)
Tenure	4 (3.5%)	8 (10.4%)	17 (12.5%)
Mobility	2 (1.8%)	2 (2.6%)	8 (5.9%)
PhD system	0 (0%)	0 (0%)	0 (0%)
Recruitment	8 (7.1%)	4 (5.2%)	4 (2.9%)
Graduate school	1 (0.9%)	2 (2.6%)	1 (0.7%)
Minority scientist	0 (0.0%)	0 (0.0%)	0 (0.0%)
Woman scientist	0 (0.0%)	0 (0.0%)	0 (0.0%)
Women scientists	2 (1.8%)	0 (0.0%)	0 (0.0%)
Female scientist	1 (0.9%)	0 (0.0%)	0 (0.0%)
Academic job	0 (0.0%)	1 (1.3%)	0 (0.0%)
Junior researcher	0 (0.0%)	0 (0.0%)	0 (0.0%)
Senior scientist	0 (0.0%)	1 (1.3%)	7 (5.1%)
Senior researcher	0 (0.0%)	1 (1.3%)	3 (2.2%)
Postgraduate training	1 (0.9%)	1 (1.3%)	0 (0.0%)
Minorities	2 (1.8%)	2 (2.6%)	4 (2.9%)

Table S3. Terms used for document map based on automatic term identification (526 terms selected)

Included (495 terms)		Excluded (31 terms)	
1	aaas	20	anything
2	absence	25	april
3	academic	123	day
4	academic institution	168	everything
5	academy	188	first time
6	action	216	handful
7	administration	223	hour
8	advance	224	http
9	advancement	226	hundred
10	africa	251	july
11	agency	252	june
12	agriculture	255	last week
13	aids	266	long term
14	allegation	267	long way
15	america	272	many country
16	american association	273	many scientist
17	analysis	274	march
18	animal	321	none
19	announcement	323	nothing
21	apology	325	november

22	applicant	331	october
23	application	343	past decade
24	appointment	344	past few year
26	argument	350	period
27	article	397	recent year
28	asia	452	someone
29	assessment	453	something
30	attempt	479	ten
31	author	482	third
32	authority	516	whole
33	autonomy	517	wide range
34	award		
35	background		
36	barrier		
37	basic research		
38	basis		
39	behalf		
40	behaviour		
41	best practice		
42	best scientist		
43	bill		
44	biologist		
45	biology		
46	biomedical research		
47	blog		
48	book		
49	bottom		
50	brain		
51	brazil		
52	breakthrough		
53	britain		
54	budget		
55	bush		
56	bush administration		
57	business		
58	busquin		
59	california		
60	cambridge		
61	campaign		
62	canada		
63	capacity		
64	career path		
65	case		
66	cause		

67	cell
68	centre
69	cern
70	charge
71	chemistry
72	chief
73	child
74	china
75	chu
76	circumstance
77	citizen
78	claim
79	clinical research
80	clinical trial
81	cnrs
82	colleague
83	college
84	collins
85	comment
86	commission
87	common standard
88	company
89	competitiveness
90	complaint
91	concept
92	conclusion
93	conference
94	confidence
95	conflict
96	congress
97	connection
98	consciousness
99	consensus
100	conservation biologist
101	construction
102	content
103	context
104	continent
105	contract
106	contrast
107	contribution
108	control
109	cooperation
110	cost

111	council
112	country
113	course
114	creation
115	credit
116	crick
117	crisis
118	critic
119	cut
120	darpa
121	data
122	database
124	debate
125	defense
126	degree
127	delay
128	design
129	detail
130	dfg
131	difference
132	difficulty
133	director
134	disability
135	discovery
136	disease
137	diversity
138	dollar
139	doubt
140	drug
141	earth
142	economic growth
143	economy
144	editor
145	education
146	effectiveness
147	einstein
148	election
149	employee
150	employer
151	engineering
152	english
153	entry
154	epsrc
155	equipment

156	era
157	erc
158	error
159	establishment
160	ethic
161	euro
162	europe
163	european commission
164	european research area
165	european union
166	euryi
167	event
169	evidence
170	evolution
171	excellence
172	exception
173	experiment
174	expert
175	facility
176	factor
177	faculty
178	faculty member
179	family
180	fda
181	fear
182	federal government
183	fellow
184	fellowship
185	field
186	figure
187	finding
189	flexibility
190	food
191	foreign scientist
192	foreigner
193	forest
194	foundation
195	france
196	fraud
197	funder
198	funding agency
199	fursenko
200	gap
201	gdp

202	gene
203	general public
204	generation
205	german university
206	germany
207	global warming
208	government
209	government agency
210	graduate student
211	grant
212	grant application
213	graphene
214	gross domestic product
215	ground
217	harvard
218	health
219	heart
220	hicheur
221	higher education
222	host
225	hubble
227	hwang
228	ictp
229	ilc
230	impact factor
231	implementation
232	impression
233	independence
234	india
235	individual scientist
236	influence
237	information
238	infrastructure
239	inquiry
240	insight
241	instance
242	integrity
243	internet
244	investigation
245	investigator
246	investment
247	iran
248	italy
249	japan

250	journal
253	lab
254	laboratory
256	launch
257	law
258	letter
259	lhc
260	life
261	life science
262	light
263	line
264	list
265	literature
268	los alamos
269	majority
270	man
271	manuscript
275	markl
276	material
277	math
278	mathematic
280	mean
281	mechanism
282	medicine
283	medium
284	member state
285	mentor
286	mentoring
287	message
288	method
289	metric
290	mind
291	minister
292	ministry
293	minority
294	misconduct
295	mission
296	mistake
297	mobility
298	money
299	mouse
300	move
301	movement
302	name

303	nanotechnology
304	nasa
305	national academies
306	national institute
307	national science foundation
308	nature
309	nature publishing group
310	network
311	new generation
312	new government
313	new technology
314	news
315	news feature
316	next generation
317	next wave
318	nih
319	nobel prize
320	nomination
322	note
324	notion
326	nsf
327	nsfc
328	nuclear power
329	objective
330	occasion
332	office
333	official
334	opinion
335	outcome
336	pace
337	pakistan
338	panel
339	paper
340	participant
341	partnership
342	party
345	patient
346	peer
347	peer review
348	perception
349	performance
351	phd
352	phds
353	physic

354	physical science
355	physician
356	physicist
357	physics
358	plan
359	policy maker
360	politic
361	politician
362	pool
363	population
364	possibility
365	postdoc
366	postdoctoral fellow
367	power
368	practice
369	practitioner
370	predecessor
371	president
372	president obama
373	pressure
374	prime minister
375	principle
376	priority
377	prize
378	procedure
379	profession
380	program
381	promotion
382	proposal
383	prospect
384	protein
385	protest
386	public health
387	public policy
388	publication
389	publisher
390	purpose
391	quality
392	quarter
393	question
394	r & d
395	rank
396	reader
398	recognition

399	recommendation
400	record
401	recruitment
402	referee
403	reform
404	regard
405	region
406	regulation
407	relation
408	representative
409	republican
410	reputation
411	research agency
412	research community
413	research council
414	research grant
415	research institute
416	research organization
417	research university
418	respondent
419	result
420	retraction
421	review
422	reviewer
423	reward
424	right
425	risk
426	rule
427	russia
428	s & t
429	salary
430	sample
431	scale
432	sceptic
433	scheme
434	school
435	science education
436	science ministry
437	science policy
438	scientific career
439	scientific community
440	scientific misconduct
441	scientific society
442	scope

443	secretary
444	senior scientist
445	service
446	sex
447	side
448	site
449	skill
450	social science
451	social scientist
454	south africa
455	spain
456	stake
457	standard
458	state
459	status
460	stem
461	stem cell research
462	story
463	strength
464	structure
465	student
466	study
467	subject
468	summer
469	summers
470	supervisor
471	surgeon general
472	survey
473	talent
474	target
475	teacher
476	teaching
477	technique
478	technology policy
480	thank
481	theory
483	threat
484	tool
485	topic
486	training
487	transparency
488	treatment
489	trial
490	trust

491	truth
492	turkey
493	turn
494	tyndall centre
495	uncertainty
496	undergraduate
497	understanding
498	unesco
499	us congress
500	us department
501	us government
502	us national academy
503	us national institute
504	us national institutes
505	us national science foundation
506	us university
507	venezuela
508	victim
509	virus
510	vision
511	voter
512	war
513	washington
514	website
515	west
518	winner
519	woman
520	women scientist
521	worker
522	young academy
523	young investigator
524	young person
525	younger scientist
526	zerhouni

Appendix 2 (supplementary information to chapter 3)

Table S1. Overview of all current German academic positions

Position	Type	Translation	Description	Supervision	Job security
Professors					
W3 Professoren[1-4]	Full	Full professor; formerly C4 professor	Academic staff occupying a professorial chair; responsible for research and teaching of a full scientific field	Leads group and supervises junior researchers (research assistants and affiliates, and corresponding functions)	Tenured
W2 Professoren[1-4]	Full	Extraordinary professor; formerly C3 professor	Academic staff independently performing research and teaching in (parts of) a scientific field	Supervises junior researchers	Tenured or untenured with tenure track
Juniorprofessoren (W1)[1,3,4]	Full	Junior professor	Starting group leaders setting up independent lines of research. Supposed to make *Habilitation* superfluous.	Supervises a small group of junior researchers	Untenured, usually without tenure track
C4 Professoren[1-3]	Full	Full professor	See W3 Professoren	See W3 Professoren	Tenured
C3 Professoren[1-3]	Full	Extraordinary professor	See W2 Professoren	See W2 Professoren	Tenured
C2 Professoren[1-3,6]	Full	Assistant professor	Academic staff performing research and teaching relatively independently	Loosely guided by other academic staff; can supervise a small group of junior researchers	Usually untenured
Gastprofessoren (hauptberuflich)[1,7]	Full	Visiting professor (full-time)	Academic staff usually employed at another research institution temporarily filling a professorial position, performing research and teaching independently and on their own responsibility	Dependent on situation	Untenured
Lecturers					
Hochschuldozenten[1,8,9]	Full	University lecturer	Academic staff, non-professorial	Loosely guided by other academic staff; can supervise a small group of junior researchers	Untenured or tenured
Universitätsdozenten[1,10]	Full	University lecturer	Academic staff, non-professorial	Loosely guided by other academic staff; can supervise a small group of junior researchers	Untenured or tenured

Oberassistenten[1]	Full	Senior researcher	Academic staff, non-professorial	Loosely guided by other academic staff; can supervise a small group of junior researchers	Untenured or tenured
Oberingenieure[1]	Full	Senior engineer	Academic staff, non-professorial	Loosely guided by other academic staff; can supervise a small group of junior researchers	Untenured or tenured
University teachers					
Lehrbeauftragte[1,11]	Partial	Adjunct professor	Freelance teacher of specific subjects	The quality of their teaching is the responsibility of a professor	Freelance
Honorarprofessoren[1,12]	Partial	Visiting professor	Renowned part-time lecturer	Independent teachers	Untenured
Privatdozenten, außerplanmäßige Professoren[1,3,13] (until 1990: Lecturer group, from 2000: University teachers group)	Full	Private lecturers, senior private lecturers	Private lecturer: independent *Habilitation*-holding teacher; senior private lecturer title is given to private lecturers who have held the private lecturer title for 2-6 years (depending on state). Used to be the main position below the professoriate, but has been replaced by junior and extraordinary professors. We adhere to the *Statistisches Bundesamt* classification by grouping them into the Lecturer group until 1990, but from 2000 into the University teachers group.	Independent teachers	Untenured
Studienräte, -direktoren im Hochschuldienst[2]	Full	Teacher	PhD-holding person hired mostly for teaching		Typically tenured
Fachlehrer, Technische Lehrer[14,15]	Full	Vocational teacher	Teacher of a specific subject		
Lektoren[16]	Full	Philology teachers	Teachers hired to teach their native language; as a temporary position usually a job for a PhD candidate, as a tenured position usually a job for one to stay in while one waits to take a professorial chair	Independent teachers	Both untenured and tenured

Sonstige Lehrkräfte für besondere Aufgaben[1]	Full	Other university teachers	Teachers not categorized into other university teachers positions	Dependent on situation	Dependent on situation
Gastprofessoren (nebenberuflich)[7]	Partial	Part-time visiting professors	Academic staff usually employed at another research institution temporarily filling a professorial position, performing research and teaching independently and on their own responsibility	Dependent on situation	Untenured
Tutoren[1,17]	Partial	Teaching assistants	Bachelor, Master or PhD students helping to teach a course.	Supervised by professor or other academic employee	Untenured
Research affiliates and assistants					
Hochschulassistenten[1]	Full	Senior research affiliate	Former designation for the position now called *wissenschaftliche Mitarbeiter/ Assistent*	Supervised by professor; might supervise or train a few junior researchers	Typically untenured
Wissenschaftliche und künstlerische Assistenten[1,2,18-20]	Full	Senior research affiliate	Senior researchers performing research and teaching under the supervision of a professor. The term was first used in the literal meaning of assistant, and then changed to mean research assistant/ affiliate, but the latter meaning has been taken by *wissenschaftliche Mitarbeiter*, while *Assistenten* became more senior.	Supervised by professor; might supervise or train a few junior researchers	Supervised by professor; might supervise or train a few junior researchers
Wissenschaftliche und künstlerische Mitarbeiter im Angestelltenverhältnis[1,2,18-20]	Full	Research affiliate	Junior researchers (postdocs and PhD students) performing research and teaching under the supervision of a professor	Supervised by a professor or lecturer	Currently typically untenured, but in the past could be a permanent position
Akademische Mitarbeiter in Brandenburg[1,2,18-20]	Full	Research affiliate	Junior researchers (postdocs and PhD students) performing research and teaching under the supervision of a professor (specific to the state of Brandenburg)	Supervised by a professor or lecturer	Currently typically untenured, but in the past could be a permanent position

Studentische Hilfskräfte[1,21]	Partial	Research assistant	Student assisting in research projects, often to fund own PhD research. *Note: bachelor and master students can be grouped into this category as well.*	Supervised by a professor, lecturer or research affiliate	Untenured
Other					
Akademische (Ober)Räte auf Zeit[2,22]	Full	Research affiliate/ senior research affiliate	Researchers performing research and teaching under the supervision of a professor (*Akademische Räte auf Zeit*) or senior researchers who fulfill the requirements for a professorship but have not obtained one yet (*Akademische Oberräte auf Zeit*)	*Akademische Räte auf Zeit* are supervised by professors; *Akademische Oberräte* have more autonomy	Untenured
Akademische Räte, Oberräte und Direktoren[2,22]	Full	Research affiliate/ senior research affiliate	Researchers performing research and teaching under the supervision of a professor	Supervised by a professor	Currently typically untenured, but could be a permanent position in the past
Abolished positions					
Ordentliche öffentliche Professoren (Professor group)[2,3]	Full	Ordinary full professor	Similar to W3 professors	Similar to W3 professors	Tenured
Planmäßige außerordentliche Professoren (Professor group)[2,3]	Full	Extraordinary professor	Similar to W2 professors	Similar to W2 professors	Tenured

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Table S2. Research affiliates paid from third-party funding

Year	Paid from third-party funding (*Drittmittel*)
1975[1]	15.8%
1980[2]	21.4%
1990[3]	31.8%

*The number of research affiliates paid from third-party funding ("*aus Sachmitteln und mitteln dritter Finanz-Personal*" for 1975, "*aus Drittmitteln*" for 1980 and 1990) was divided by the total number of occupied research affiliates positions. Numbers for 1980 and 1990 were for all higher education institutions (*Hochschulen*) as no separate statistics were available for universities only.

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Table S3. Average age at PhD graduation

Year	*Average age at PhD graduation*
1977[1]	31.0
1981[1]	31.4
1986[1]	31.5
1988[2]	31.5
1989[2]	31.6
1990[2]	31.7
1991[2]	31.8
1996-1999[3]	32.6
2003[4]	33.0
2011[5]	32.7

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Table S4. Average age at first professorship

Year	All types of professors	Full professors (*ordentliche öffentliche Professoren* or *C4 Professoren*)	Extraordinary professors (*C3 Professoren*)	Assistant professors (*C2 Professoren*)
1860-1869[1]		37.0		
1870-1879[1]		35.7		
1880-1889[1]		36.7		
1890-1899[1]		38.7		
1900-1909[1]		39.8		
1933-1945[2]	35.3-45.0			
1946-1955[2]	40.0-53.5			
1956-1960[2]	37.4-51.1			
1977[3]	38.1			
1983[4]		39.0[§]	40.0[§]	40.2[§]
1989[4]		38.8[§]	39.8[§]	40.4[§]
1993[*,5]	41.4			
1996[*,5]	41.8			
1999[*,5]	41.8			
2003[6]	41.1			
2010[7]	41.0			

*Only habilitated professors.
[§]It is remarkable that the data from the original publication show the lowest average age for the most senior position, and higher average ages for lower positions. We suspect these data may have been switched.

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Appendix 3 (supplementary information to chapter 4)

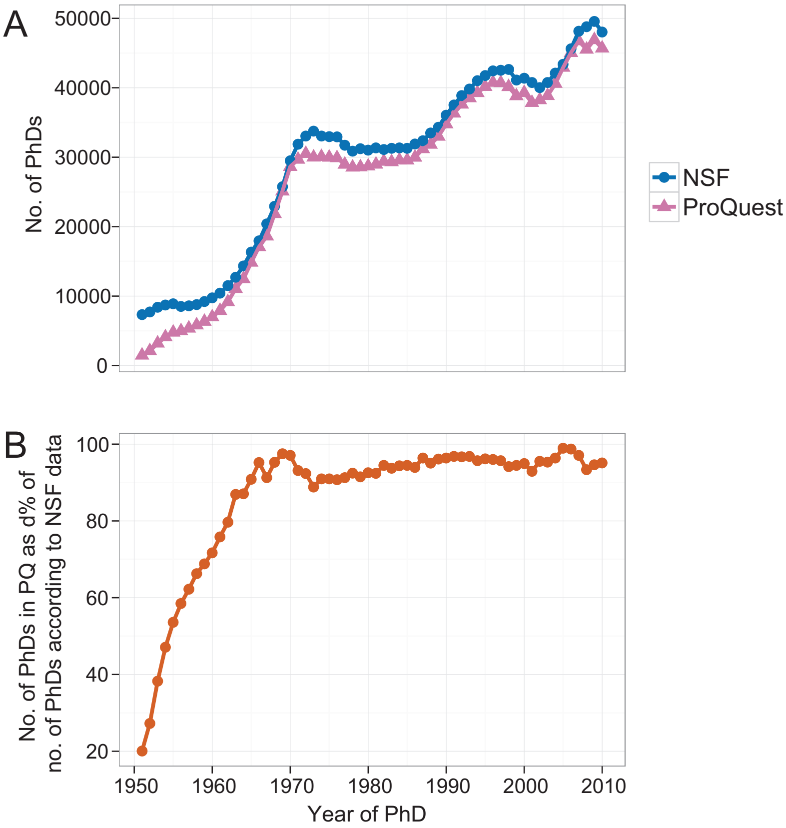

Figure S1. Trends in awarded U.S. doctorates in NSF data and the ProQuest database. (A) Annual number of doctorate recipients according to National Science Foundation data and annual number of dissertations indexed in ProQuest. (B) Number of doctoral dissertations stored in ProQuest divided by number of doctorate recipients according to NSF data.

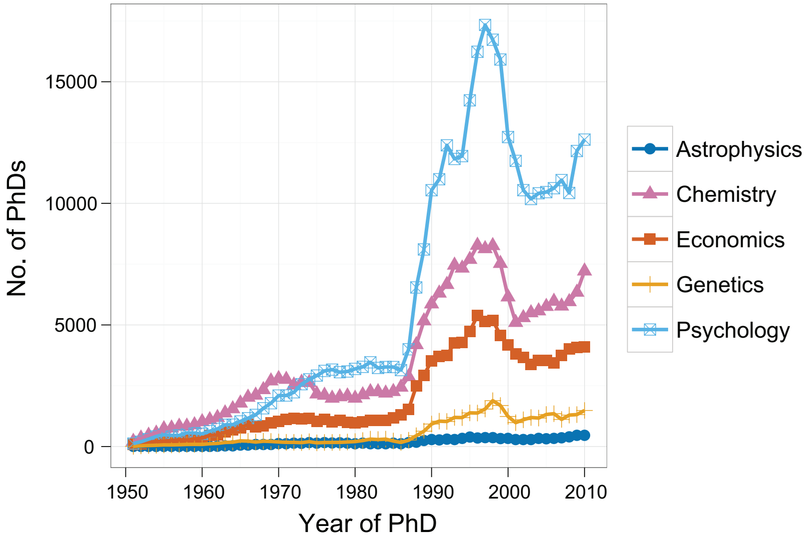

Figure S2. Annual number of U.S. doctorate recipients indexed in ProQuest, by field.

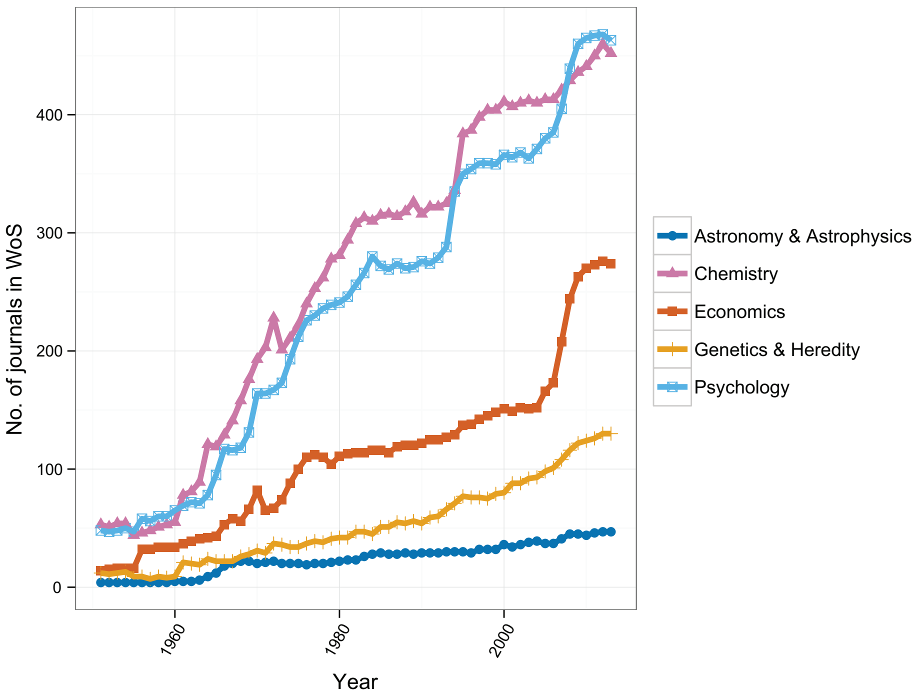

Figure S3. Number of journals indexed in Web of Science, by field and year.

Table S1. Share of women among U.S. doctoral recipients with unique names

Astrophysics	Male	Female	Other
1951-1960	93%	0%	7%
1961-1970	90%	8%	2%
1971-1980	88%	8%	3%
1981-1990	83%	13%	5%
1991-2000	77%	16%	8%
2001-2010	67%	24%	9%
Total	78%	16%	7%
Chemistry	Male	Female	Other
1951-1960	89%	6%	5%
1961-1970	84%	9%	6%
1971-1980	80%	14%	6%
1981-1990	70%	22%	8%
1991-2000	62%	30%	8%
2001-2010	58%	34%	8%
Total	70%	22%	7%
Economics	Male	Female	Other
1951-1960	88%	5%	7%
1961-1970	86%	6%	9%
1971-1980	82%	9%	9%
1981-1990	71%	17%	11%
1991-2000	65%	25%	10%
2001-2010	59%	27%	14%
Total	71%	18%	10%
Genetics	Male	Female	Other
1951-1960	77%	13%	9%
1961-1970	71%	19%	10%
1971-1980	64%	29%	7%
1981-1990	59%	35%	7%
1991-2000	51%	41%	8%
2001-2010	46%	44%	10%
Total	53%	38%	9%
Psychology	Male	Female	Other
1951-1960	79%	16%	5%
1961-1970	75%	21%	4%
1971-1980	61%	34%	4%
1981-1990	45%	50%	5%
1991-2000	36%	61%	3%
2001-2010	30%	61%	9%
Total	44%	50%	5%

Table S2. Broader research field for each group of doctorate recipients

Field of U.S. doctorate recipients	WoS citation index	Additional WoS subdisciplines
Astrophysics	SCIE	
Chemistry	SCIE	
Economics	SSCI and AHCI	Biology[a] Clinical medicine Earth and space Engineering and technology Mathemathics
Genetics	SCIE	Psychology Health
Psychology		Psychology[b] Arts Biomedical research Clinical medicine Engineering and technology Health Humanities Professional fields

Abbreviations: SCIE – Science Citation Index Expanded, SSCI – Social Science Citation Index, AHCI – Arts and Humanities Citation Index

[a] Defining this fairly broad range of disciplines and subdisciplines was necessary in order not to exclude economists in agricultural economics, health economics, environmental economics, and the more mathematical economics.

[b] This broad range was needed so not to exclude psychologists working in the more clinical fields, linguistics, visual or auditory processing, or social work

Table S3. Share of doctorate recipients with a unique name relative to total number of doctorate recipients (for whom a name is given in ProQuest), by year and discipline

Year of PhD	Astrophysics	Chemistry	Economics	Genetics	Psychology
			%		
1951-1955	25	27	26	28	26
1956-1960	25	30	28	29	28
1961-1965	25	30	29	32	28
1966-1970	25	30	30	28	31
1971-1975	35	31	30	30	31
1976-1980	32	33	30	33	33
1981-1985	35	34	30	35	32
1986-1990	31	32	27	33	32
1991-1995	29	27	24	27	28
1996-2000	32	28	25	28	31
2001-2005	29	29	22	27	30
2006-2010	27	25	19	27	28
Total	30	29	26	29	30

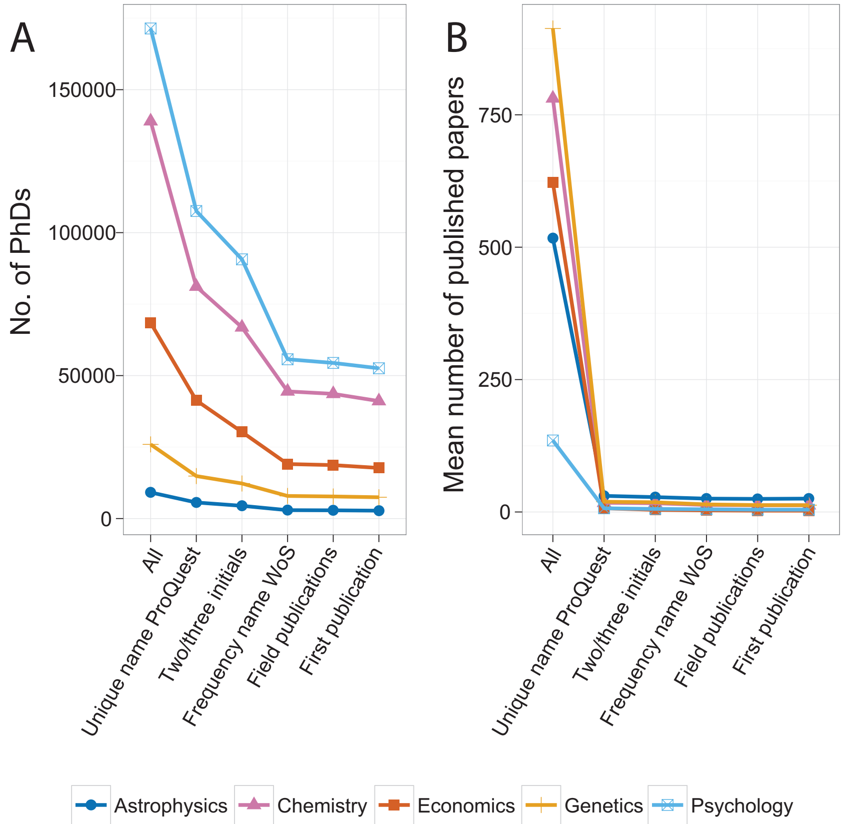

Figure S4. Selection of U.S. doctorate recipients with unique names. The used parameters were selection for names (combination of surname and one of more initials) unique in ProQuest ("Unique name ProQuest"), having two or three initials ("Two/three initials"), having a rare surname according to WoS (having a surname that does not occur in more than 100 surname-initial combinations in WoS; "Frequency name WoS"), not publishing outside of the own field and related disciplines ("Field publications"), and having the first publication up to three (astrophysics, chemistry and genetics) or five years (economics and psychology; "First publication") after PhD. (A) Number of remaining doctorate recipients in the selected sample after each selection step. (B) Mean number of published papers by doctorate recipients in the selected sample after each selection step.

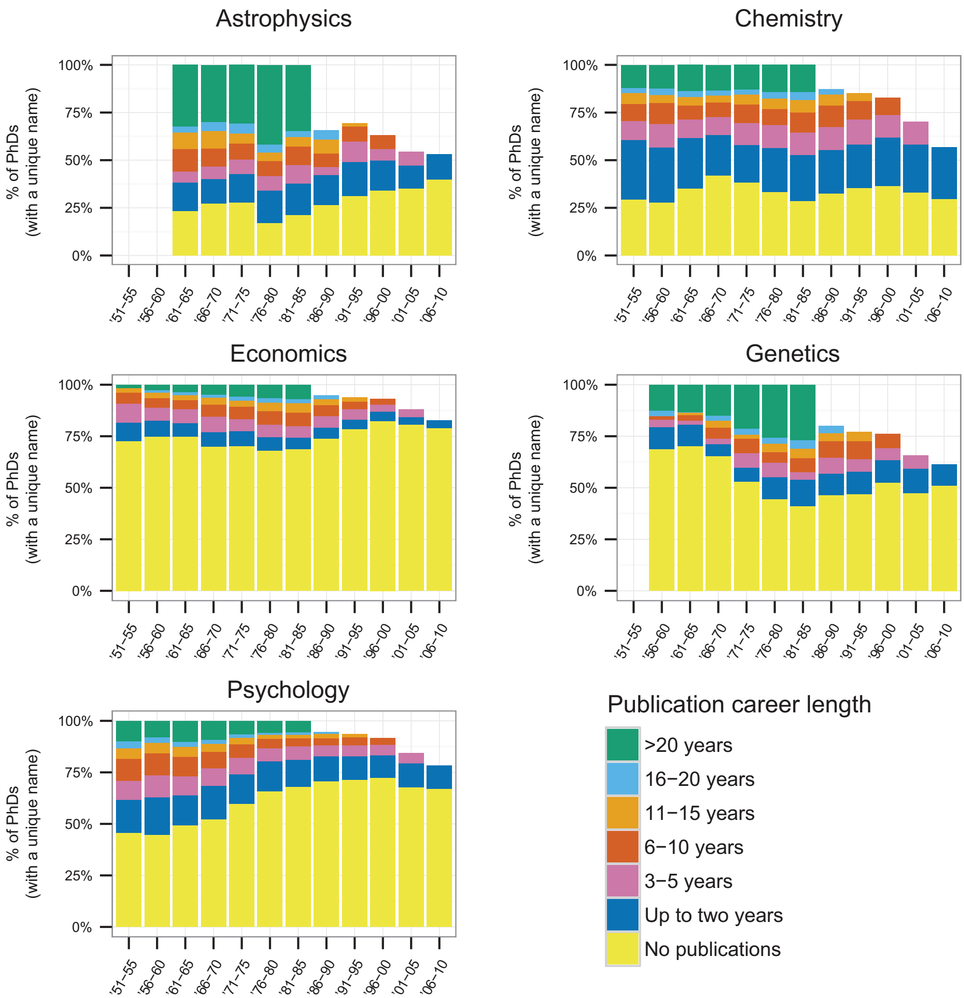

Figure S5. Career length by five-year period and field including non-publishing doctorate recipients. Papers published after publications interruptions of over five years removed (only plotted when number of doctorate recipients with one or more published papers in a five-year period > 25, and when all doctorate recipients in a five-year period have had the opportunity to publish in a given period).

Appendix 4 (supplementary information to chapter 5)

Supplementary data and methods

Construction of nationality variable

In our exploratory data analysis, we compared the perception of career prospects in academia between PhD graduates with and without the Dutch nationality, and found that Dutch nationals were more negative about prospects than non-Dutch ones. However, when looking more deeply into the data, we found that this effect was not restricted to the Netherlands, and that nationals from many countries with a high standard of living were quite negative, whereas PhDs from developing countries were more positive. Therefore, we constructed our nationality variable to reflect this distinction. Our nationality variable measures whether a PhD has the nationality from one of 21 OECD countries with a per capita Gross Domestic Product greater than $32,000 Purchasing Power Parity in 2012 (according to the UNESCO Institute for Statistics data). These countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom of Great Britain and Northern Ireland, and the United States of America.

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Supplementary tables and figures

Table S1. Description and reliability of coding classification

Main category	Subcategory	Description = coding rules
Career prospects	Long-term career prospects	Career prospects in the long term were mentioned/played a role
	Job security	Job security in the present job, including the prospect of a permanent position at the current employer. was mentioned/played a role
	Quality of HRM/career policy	The quality of HRM/career policy was mentioned/played a role
	Degree to which job provided opportunities for career advancement	Degree to which job provided opportunities for career advancement was mentioned/played a role (i.e., the current job choice was instrumental for the career)
	Required mobility	Required mobility in the chosen career was mentioned/played a role
	Job availability	Job availability in general was mentioned/played a role
No alternative job available	No alternative job available	The current job was available; no other job was
Job attributes	Creativeness	Creativeness required in the current job mentioned/played a role
	Intellectual challenge	Intellectual challenge in the current job mentioned/played a role
	Level of responsibility	Level of responsibility in the current job mentioned/played a role
	Degree of independence	Degree of independence in the current job mentioned/played a role
	Workload	(Expected) workload in the current job mentioned/played a role
	Infringement of job on personal life	(Expected) infringement of job on personal life in the current job mentioned/played a role, i.e., work-life balance
	Personal development	Possibility for personal development or to develop new skills in the current job mentioned/played a role
	Practical application and contribution to society	Practical application of research and/or contribution to society, including health care, in the current job mentioned/played a role
	Social status	Social status in the current job mentioned/played a role
	Colleagues/teamwork/work environment	Colleagues/teamwork/work environment in the current job mentioned/played a role
	Fit with interest, previous experience and/or skills	Objective correspondence with interest/previous experience/skills in the current job mentioned/played a role (e.g., "job is interesting", "fits with my previous job", "I trained to be a neurologist and now I work as a neurologist")

	International character	International character of the job mentioned/played a role
	Job satisfaction	Current job provides job satisfaction; the job or activities in it are liked, desirable or wanted (e.g., “I like my job”).
	Management position	In the current job the fact the respondent could have a management position mentioned/ played a role
	Pressure due to competition, obtaining grants and publishing	Pressure due to competition, obtaining grants and publishing was mentioned/played a role
	Variety in work	The (expected) variety in the current job, including the combination of two or more job activities, mentioned/played a role
Terms of employment	Pecuniary rewards	Pecuniary rewards (e.g., salary) mentioned/played a role
	Support by organization	Support by the organization mentioned/played a role
Personal circumstances	Partner or family	Personal circumstances: partner or family mentioned/played a role in job choice
	Location and travelling distance	Location or the travelling distance from home to work mentioned/played a role
	Other personal circumstances	Other personal circumstances (i.e., not one of the other two categories)
Fit with career goal	Career in academia	The current job was a fit with the career goal of having a career in academia
	Career outside academia	The current job was a fit with the career goal of having a career outside academia
	Career development	Career development in general (e.g., “like to grow in career”)
	Career in general	Career in general; everything to do with career that is not quite a specific career goal or career development
Other	Other	Every other reason not in one of the categories above
None	None	No factor played a role
	No answer	Everything where something has been filled in but it does not mean anything (e.g., “-”)

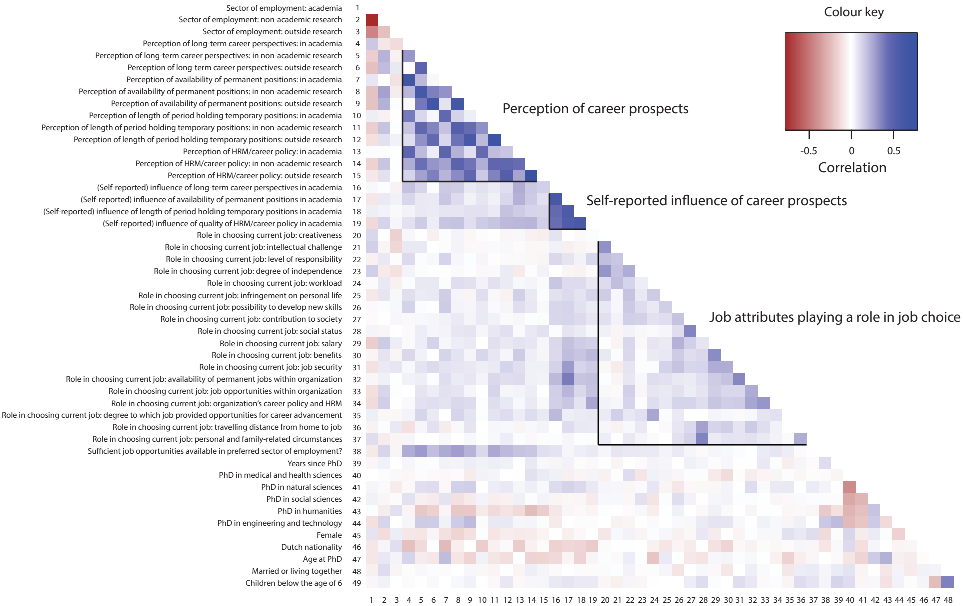

Figure S1. Heat map of correlations

Table S2. Employment status of respondents

Employment status	N (%)
Employed	**1055 (96.3)**
of which (multiple answers possible):	
Employee	979 (89.3)
Self-employed	95 (8.7)
Working paid or unpaid for own or family's business	17 (1.6)
Away from work ill, on maternity leave or temporarily laid off	22 (2.0)
Doing any other kind of paid work	9 (0.8)
Unemployed	**27 (2.5)**
of which (multiple answers possible):	
Looking for job	27 (2.5)
Waiting to start job	3 (0.3)
Inactive	**14 (1.3)**
of which (multiple answers possible):	
Retired	5 (0.5)
Student	-
Looking after home or family	4 (0.4)
Long-term sick or disabled	1 (0.1)
Other	6 (0.5)
Total	**1096 (100)**

Appendix 5 (supplementary information to chapter 6)

Table S1. Employment status by sector of work

Type of employment contract	Academia	Non-ac. res.	Outside res.	Total
		%		
All				
Permanent	42	66	55	50
Probation period of permanent contract	3	3	4	3
Temporary with tenure track	9	1	2	6
Temporary without prospect of permanence	46	11	26	34
Self-employed	0	19	13	7
1-3 years after PhD				
Permanent	28	59	59	39
Probation period of permanent contract	4	5	3	4
Temporary with tenure track	8	0	3	5
Temporary without prospect of permanent contract	61	20	26	46
Self-employed	0	16	9	5
4-5 years after PhD				
Permanent	48	69	53	55
Probation period of permanent contract	2	3	5	3
Temporary with tenure track	10	1	1	6
Temporary without prospect of permanent contract	40	7	26	28
Self-employed	0	20	15	8

Table S2. Rotated factor loadings based on a principal components extraction with promax rotation ($\kappa = 4$) and three factors for eighteen items of job satisfaction (incl. reliability of resultant scales)

	Factor 1 Terms of employment	Factor 2 Job content	Factor 3 Work-life balance
Intellectual challenge		0.860	
Degree of independence		0.644	
Creativeness		0.821	
Level of responsibility		0.690	
Possibility to develop new skills		0.684	
Contribution to society	0.212	0.486	
Social status	0.313	0.410	
Salary	0.471		
Job security	0.844		
Degree to which job provides opportunities for career advancement	0.437	0.311	
Benefits	0.456		
Permanent jobs within organization	0.918		
Organization's career policy and HRM	0.685		
Job opportunities within organization	0.867		
Infringement of job on personal life			0.769
Workload			0.576
Personal circumstances			0.794
Travelling distance			0.644
Cronbach's α	*0.81*	*0.83*	*0.65*[a] *0.77*[b]

[a] For all four items
[b] For "infringement of job on personal life" and "workload" only
Note: factor loadings < .2 suppressed

Table S3. Effects of employment, PhD and personal characteristics on three scales of job satisfaction, incl. part-time employment (linear regression)

	Job content		Terms of employment		Work-life balance	
	B (S. E.)	p-value	B (S. E.)	p-value	B (S. E.)	p-value
Intercept	3.79 (0.11)	< 0.001***	3.43 (0.12)	< 0.001***	3.32 (0.17)	< 0.001***
Employment status (ref. is permanent contract)						
Probation period of permanent contract	-0.20 (0.14)	0.138	-0.13 (0.14)	0.334	-0.03 (0.20)	0.880
Temporary contract with tenure track	-0.04 (0.10)	0.668	-0.35 (0.10)	< 0.001***	-0.34 (0.14)	0.017*
Temporary contract without prospect of permanence	-0.14 (0.06)	0.016*	-0.72 (0.06)	< 0.001***	0.05 (0.09)	0.569
Other employment characteristics						
Part-time employment	0.04 (0.06)	0.532	-0.12 (0.06)	0.049*	-0.14 (0.09)	0.120
Supervisory role in job	0.11 (0.05)	0.019*	0.12 (0.05)	0.021*	-0.02 (0.07)	0.728
Educational level required for job (ref. is PhD)						
Bachelor or lower	-0.48 (0.17)	0.004**	-0.67 (0.17)	< 0.001***	-0.08 (0.24)	0.748
Master	-0.23 (0.07)	< 0.001***	0.10 (0.07)	0.175	0.10 (0.10)	0.323
Professional degree (e.g., M. D.)	-0.02 (0.08)	0.843	0.11 (0.08)	0.198	-0.51 (0.12)	< 0.001***
Sector of work (ref. is academia)						
Non-academic research	-0.09 (0.06)	0.168	0.21 (0.06)	0.001**	0.09 (0.09)	0.298
Outside research	-0.10 (0.08)	0.244	0.12 (0.08)	0.170	0.07 (0.12)	0.584
Having mentor in current job	0.18 (0.05)	< 0.001***	0.09 (0.05)	0.077	0.06 (0.07)	0.406
Years in job	0.00 (0.01)	0.464	-0.02 (0.01)	< 0.001***	-0.02 (0.01)	0.002**
PhD characteristics						
Field of PhD (ref. is engineering and technology)						
Medical and health sciences	-0.06 (0.09)	0.458	-0.07 (0.09)	0.431	-0.07 (0.13)	0.582
Natural sciences	0.06 (0.08)	0.452	0.15 (0.09)	0.095	-0.10 (0.12)	0.417
Social sciences	-0.09 (0.10)	0.359	0.00 (0.10)	0.967	-0.09 (0.14)	0.522
Humanities	0.03 (0.10)	0.766	-0.12 (0.10)	0.229	-0.34 (0.14)	0.018*
Personal characteristics						
Dutch	0.07 (0.06)	0.267	-0.03 (0.06)	0.598	0.01 (0.09)	0.880
Female	-0.02 (0.05)	0.622	0.02 (0.05)	0.709	-0.12 (0.07)	0.097
Living with partner	-0.01 (0.06)	0.900	-0.03 (0.06)	0.669	0.08 (0.09)	0.359
Children below 6	0.11 (0.05)	0.040*	0.00 (0.05)	0.930	0.08 (0.08)	0.284

*, **, and *** denote statistically significant difference of the independent variable at the 5, 1, and 0.1% levels, respectively.

Appendix 6 (supplementary information to chapter 7)

Table S1. Pearson's correlations between main background variables

	Internal PhD	Faculty: humanities	Faculty: law	Faculty: science	Faculty: social and behavioural sciences	Faculty: other	Female	Dutch	Year of PhD
Internal PhD	1								
Faculty: humanities	-0.302***	1							
Faculty: law	-0.031	-0.208**	1						
Faculty: science	0.234***	-0.636***	-0.258***	1					
Faculty: social and behavioural sciences	0.130	-0.270***	-0.109	-0.334***	1				
Faculty: other	-0.059	-0.098	-0.040	-0.121	-0.051	1			
Female	0.005	0.108	0.079	-0.273***	0.221**	-0.065	1		
Dutch	0.357***	-0.047	0.067	-0.068	0.158*	-0.127	-0.075	1	
Year of PhD	0.037	0.075	0.041	-0.027	-0.083	-0.042	-0.010	0.134*	1

Table S2. Non-response analysis by type of appointment and faculty

Faculty	University total – internal	Respondents – internal	University total – external	Respondents – external
	% (of university or respondent group)			
Humanities	17	24	45	55
Law	11	7	17	9
Science	53	51	21	26
Social and behavioural sciences	16	16	10	6
Other	4	1	6	3

The number of internal PhD candidates at Leiden University is the number of *aio's* given in Full Time Equivalents (FTE). The number of external PhD candidates is given in persons. Numbers of PhD candidates at Leiden University are for April 2013. Please note that numbers of external PhD candidates are estimates, as they are not always registered at the faculties. Data were kindly provided by Floor Frederiks, directorate Academic Affairs, Leiden University. Percentages may not add up to 100 due to rounding.

Table S3. Offered facilities

Facilities	Internals	Externals	Total	p-value
		%		
Own desk	89	53	79	< 0.001***
Shared desk	10	18	12	0.127
Own computer	84	51	75	< 0.001***
Shared computer	9	13	10	0.396
Free printing	90	55	80	< 0.001***
Free telephone	90	47	78	< 0.001***
None	2	24	8	< 0.001***

P-values from Pearson's chi-squared test of independence between the availability of facility and type of appointment.

Table S4. Logistic regression on availability of several facilities by employment status, controlling for other variables

	B (S. E.)	p-value
Shared desk		
Constant	-2.55 (0.76)	< 0.001***
Internal (dummy)	-1.06 (0.57)	0.064
Faculty (ref. is humanities)		
Law	-19.04 (10518.96)	0.999
Science	0.23 (0.59)	0.696
Social and behavioural sciences	1.36 (0.65)	0.037*
Year of PhD	0.18 (0.16)	0.285
Female (dummy)	0.51 (0.51)	0.320
Dutch (dummy)	0.35 (0.53)	0.506
Cox & Snell R^2	*0.069*	
Shared computer		
Constant	-2.27 (0.80)	0.004**
Internal (dummy)	-0.83 (0.60)	0.165
Faculty (ref. is humanities)		
Law	-0.12 (1.14)	0.913
Science	0.58 (0.63)	0.359
Social and behavioural sciences	0.44 (0.80)	0.581
Year of PhD	-0.06 (0.17)	0.742
Female (dummy)	0.34 (0.53)	0.528
Dutch (dummy)	0.57 (0.56)	0.305
Cox & Snell R^2	*0.015*	
Free printing		
Constant	0.77 (0.60)	0.200
Internal (dummy)	2.12 (0.50)	< 0.001***
Faculty (ref. is humanities)		
Law	0.16 (0.78)	0.833
Science	0.91 (0.52)	0.079
Social and behavioural sciences	-0.21 (0.65)	0.744
Year of PhD	-0.25 (0.14)	0.089
Female (dummy)	-0.13 (0.44)	0.774
Dutch (dummy)	-0.17 (0.48)	0.717
Cox & Snell R^2	*0.172*	
Free telephone		
Constant	0.57 (0.60)	0.348
Internal (dummy)	2.35 (0.48)	< 0.001***
Faculty (ref. is humanities)		
Law	0.33 (0.79)	0.677
Science	0.43 (0.49)	0.380
Social and behavioural sciences	0.60 (0.75)	0.417
Year of PhD	-0.22 (0.14)	0.125
Female (dummy)	-0.37 (0.44)	0.402
Dutch (dummy)	-0.13 (0.46)	0.783
Cox & Snell R^2	*0.200*	

No facilities		
Constant	-2.15 (0.94)	0.023*
Internal (dummy)	-3.05 (0.89)	< 0.001***
Faculty (ref. is humanities)		
Law	-0.66 (1.18)	0.573
Science	-1.18 (0.86)	0.169
Social and behavioural sciences	-0.68 (1.19)	0.567
Year of PhD	0.28 (0.23)	0.225
Female (dummy)	0.94 (0.67)	0.158
Dutch (dummy)	0.13 (0.69)	0.855
Cox & Snell R^2	*0.150*	

*, **, and *** denote statistically significant difference of the independent variable at the 5, 1, and 0.1% levels, respectively. Dummy "other" faculties not included due to low number of true cases.

Table S5. Logistic regression on work pressure and frequency of stress by type of employment, controlling for other variables

	Work pressure		**Frequency of stress**	
	B (S. E.)	p-value	B (S. E.)	p-value
Constant	-1.80 (0.53)	< 0.001***	0.14 (0.49)	0.779
Internal (dummy)	-0.16 (0.41)	0.694	-0.80 (0.40)	0.042*
Year of PhD	0.22 (0.11)	0.047*	0.09 (0.11)	0.426
Faculty (ref. is humanities)				
Law	-0.52 (0.75)	0.486	-0.93 (0.75)	0.211
Science	1.10 (0.41)	0.007**	0.23 (0.39)	0.557
Social and behavioural sciences	0.72 (0.53)	0.171	0.55 (0.52)	0.290
Female (dummy)	1.08 (0.35)	0.002**	0.54 (0.33)	0.105
Dutch (dummy)	-0.15 (0.35)	0.678	-0.69 (0.34)	0.044*
Cox & Snell R^2	*0.109*		*0.096*	

*, **, and *** denote statistically significant difference of the independent variable at the 5, 1, and 0.1% levels, respectively. Dummy "other" faculties not included due to low number of true cases.

Table S6. Sources of stress

Source of stress	Total	Internal	External	p-value
		%		
Pressure to publish	47	52	33	0.024*
Deadlines	46	46	46	0.936
Difficulty of work	38	38	39	0.913
Amount of work	36	33	41	0.335
Contact with managers or supervisors	31	26	46	0.014*
Interruptions during work	30	28	33	0.599
Teaching duties	28	35	9	< 0.001***
Work speed	28	28	28	0.936
Drastic personal events	16	15	20	0.436
Drastic work-related events	12	11	15	0.405
Equipment	12	14	9	0.369
Work content	12	13	9	0.440
Contact with students	8	11	4	0.164
Other activities	8	7	11	0.456
Contact with colleagues	7	4	13	0.035*
Other	18	17	22	0.485

P-values from Pearson's chi-squared test of independence between the availability of facility and type of appointment.

Questionnaire

Q97 LEO Survey for PhD Candidates
This survey is conducted by LEO (*Leids Promovendi Overleg*) - the PhD organization of Leiden University. The results of this first PhD survey at Leiden University will be used to evaluate the situation of PhD Candidates and we will accordingly present the report of these results to the Rector Magnificus. The survey consists of 8 blocks and will take approximately 15 minutes to be answered. The survey is confidential and that means we will not share your personal data with third parties and only present aggregated data to university institutions. This means that your identity will not be revealed to others. We are very grateful for your participation. If you have any comments or questions please email to leoleiden.info@gmail.com

Q34 I. GENERAL The first part of the survey contains questions concerning your personal details.

Q1 What is your age?

Q2 What is your gender?
- ❍ Male (1)
- ❍ Female (2)
- ❍ no answer (3)

Q3 In what year were you appointed as a PhD Candidate?
- ❍ earlier than 2008 (1)
- ❍ 2008 (2)
- ❍ 2009 (3)
- ❍ 2010 (4)
- ❍ 2011 (5)
- ❍ 2012 (6)

Q4 How many years do you officially have for your PhD project (if not yet determined, please leave 0)?

Q5 What is your faculty?
- ❍ Archaeology (1)
- ❍ Campus The Hague (2)
- ❍ Humanities (3)
- ❍ Law (4)
- ❍ Medicine / Leiden University Medical Center (5)
- ❍ Science (6)
- ❍ Social and Behavioural Science (7)
- ❍ other (8)

Answer If What is your faculty? Humanities Is Selected

Q6 At which research institute do you work? (multiple answers possible)
- ❑ Leiden University Academy for Creative and Performing Arts (1)
- ❑ Leiden University Institute for Cultural Disciplines (2)
- ❑ Leiden University Institute for History (3)
- ❑ Leiden University Institute for Philosophy (4)
- ❑ Leiden Institute for Area Studies (5)
- ❑ Leiden Institute for Religious Studies (6)
- ❑ Leiden University Centre for Linguistics (7)
- ❑ other (8)

Answer If What is your faculty? Law Is Selected

Q98 At which research institute do you work? (multiple answers possible)
- ❑ Institute for Public Law (1)
- ❑ Institute for Criminal Law & Criminology (2)
- ❑ Institute for the Interdisciplinary Study of the Law (3)
- ❑ Institute for Tax Law and Economics (4)
- ❑ International Tax Centre Leiden (5)
- ❑ Research Institute (6)
- ❑ Grotius Centre for International Legal Studies (7)
- ❑ Cleveringa Institute (8)
- ❑ other (9)

Answer If What is your faculty? Science Is Selected

Q99 At which research institute do you work? (multiple answers possible)
- ❑ Nationaal Herbarium Nederland (1)
- ❑ Institute of Biology Leiden (2)
- ❑ Institute of Environmental Science (3)
- ❑ Leiden / Amsterdam Center for Drug Research (4)
- ❑ Leiden Institute of Advanced Computer Science (5)
- ❑ Leiden Institute of Chemistry (6)
- ❑ Leiden Institute of Physics (7)
- ❑ Leiden Observatory (8)
- ❑ Lorentz Center (9)
- ❑ Mathematical Institute (10)
- ❑ other (11)

Answer If What is your faculty? Social and Behavioural Science Is Selected

Q100 At which research institute do you work? (multiple answers possible)
- ❑ Cultural Anthropology and Development Sociology (1)
- ❑ Education and Child Studies (2)
- ❑ Political Science (3)
- ❑ Psychology (4)
- ❑ Public Administration (5)
- ❑ other (6)

Q7 Are you an international PhD Candidate? Our definition of an international PhD Candidate: a PhD Candidate who is obtaining his or her doctoral degree at Leiden University and does not have Dutch citizenship. If you have double citizenship please choose the one that is closest to your own identity.
- ❍ yes (1)
- ❍ no (2)
- ❍ I don't know (3)

Q8 Do you have an employment contract with Leiden University as a PhD Candidate?
- ❍ Yes (1)
- ❍ No (2)
- ❍ I don't know (3)

Q35 II FINANCIAL SITUATION The second part of the survey concerns your financial situation.

Q9 Who is funding your position at Leiden University? (multiple answers possible).
- ❑ Leiden University (1)
- ❑ Another university in the Netherlands (2)
- ❑ NWO (3)
- ❑ Dutch state authorities (except NWO) (4)
- ❑ Another Dutch research funding organization (5)
- ❑ Dutch private business (6)
- ❑ Non-Dutch university (7)
- ❑ Non-Dutch state authorities (8)
- ❑ Another non-Dutch research funding organization (9)
- ❑ Non-Dutch private business (10)
- ❑ Savings (11)
- ❑ Other employment next to your PhD position (12)
- ❑ Private funders such as relatives or friends (13)
- ❑ other (14)

Q10 What is your monthly disposable income? We define disposable income as your total personal income (from your salary but also from a bursary) from your PhD position minus personal current taxes.
- ❍ 0-500 Euro (1)
- ❍ 500-1000 (2)
- ❍ 1000-1500 (3)
- ❍ more than 1500 (4)

Q11 How much funding is available to you for research material, research trips and training related to your PhD project?
- ❍ Sufficient (1)
- ❍ Not sufficient (2)
- ❍ I don't have any financial means available (3)

Answer If How much funding is available to you for research material, research trips and training related to your PhD project? I don't have any financial means available Is Not Selected

Q12 Who pays for your research material, research trips and training? (multiple answers possible).
- ❑ Leiden University (1)
- ❑ Another university in the Netherlands (2)
- ❑ NWO (3)
- ❑ Dutch state authorities (except NWO) (4)
- ❑ Another Dutch research funding organization (5)
- ❑ Dutch private business (6)
- ❑ Non-Dutch university (7)
- ❑ Non-Dutch state authorities (8)
- ❑ Another non-Dutch research funding organization (9)
- ❑ Non-Dutch private business (10)
- ❑ Savings (11)
- ❑ Other employment next to your PhD position (12)
- ❑ Private funders such as relatives or friends (13)
- ❑ other (14)
- ❑ I do not know (15)

Q13 III. GENERAL SUPPORT AND SERVICES This section concerns the support and services that Leiden University offers to PhD Candidates.

Q14 Introduction to Leiden University In what way have you been introduced to your (main) research institute? (multiple answers possible).
- ❑ I have not been introduced to my research institute (1)
- ❑ By information provided by the Human Resources Department (2)
- ❑ By a letter of the research institute (3)
- ❑ By a PhD guide at the start of my PhD project (4)
- ❑ By introduction day(s) at the start of my PhD project (5)
- ❑ By my supervisor(s) (6)
- ❑ By colleagues and other PhD Candidates (7)

Q15 Office Space and Computer Do you have access to (multiple answers possible)
- ❑ Office desk used only by yourself (1)
- ❑ Office desk shared with others (2)
- ❑ Computer used only by yourself (3)
- ❑ Computer shared with others (4)
- ❑ Free access to telephone (5)
- ❑ Free access to printers (6)
- ❑ none of the above (7)

Answer If Office Space and Computer Do you have access to (multiple answers possible) none of the above Is Not Selected

Q17 How satisfied are you with your office space?
- ❍ Very satisfied (1)
- ❍ Satisfied (2)
- ❍ Neutral (3)
- ❍ Dissatisfied (4)
- ❍ Very dissatisfied (5)

Answer If How satisfied are you with your office space? Dissatisfied Is Selected Or How satisfied are you with your office space? Very dissatisfied Is Selected

Q18 You have indicated that you are not satisfied with your office space conditions could you please elaborate why?

Q20 PhD Courses offered by Leiden University Leiden University offers to its PhD Candidates a number of Generic Skills Courses such as effective communication, time management and intellectual property.

Q19 Before taking this survey were you familiar with Leiden University's Generic Skills Course selection?
- ❍ Yes (1)
- ❍ No (2)

Answer If Before taking this survey were you familiar with Leiden University's Generic Skills Course selection? Yes Is Selected

Q21 Have you ever taken any of the Generic Skills Courses at Leiden University?
- ❍ Yes (1)
- ❍ No (2)
- ❍ I do not know (3)

Answer If Have you ever taken any of the Generic Skills Courses at Leiden University? Yes Is Selected

Q22 How satisfied are you with Leiden University's General Skills Course selection?
- Very Satisfied (1)
- Satisfied (2)
- Neutral (3)
- Dissatisfied (4)
- Very Dissatisfied (5)

Q23 Confidential Advisor
Every institute or department should have a confidential advisor for its PhD Candidates. The tasks of this confidential advisor is to act as a contact point for PhD Candidates who are experiencing a problem or conflict with regard to training, support and/or assessment. After consultation with the PhD Candidate, the Confidential Advisor should be able to approach the most appropriate person to handle the problem or conflict and solve it if possible.

Q24 Do you know about the confidential advisor of your institute or department?
- Yes (1)
- No (2)

Answer If Do you know about the confidential advisor of your institute or department? Yes Is Selected

Q25 Have you ever been in contact with this confidential advisor?
- Yes (1)
- No (2)

Answer If Have you ever been in contact with this confidential advisor? Yes Is Selected

Q26 How satisfied are you with the contact that you had with the confidential advisor?
- Very Satisfied (1)
- Satisfied (2)
- Neither dissatisfied nor satisfied (3)
- Dissatisfied (4)
- Very Dissatisfied (5)

Answer If Are you an international PhD Candidate? yes Is Selected

Q28 Many formal and practical affairs have to be arranged before coming to the Netherlands as an international PhD Candidate. The following questions concern this topic.

Answer If Are you an international PhD Candidate? yes Is Selected

Q29 How would you describe the overall process of coming to the Netherlands?
- Very easy (1)
- Easy (2)
- Neither difficult nor easy (3)
- Difficult (4)
- Very difficult (5)

Answer If Are you an international PhD Candidate? yes Is Selected

Q30 What kind of problems did you encounter before or/and during your stay in the Netherlands? (multiple answers are possible).
- ❑ Immigration Services (1)
- ❑ Housing (2)
- ❑ Health Care (3)
- ❑ Socializing (4)
- ❑ Language (5)
- ❑ Financial issues (6)
- ❑ other (7)

Answer If You have indicated that you encountered other problems before or during your stay in the Netherlands. Would you please let us know which kind of problems? Is Selected

Q31 You have indicated that you encountered other problems before or during your stay in the Netherlands. Would you please let us know which kind of problems?

Answer If Are you an international PhD Candidate? yes Is Selected

Q32 Did you receive any formal or informal support from Leiden University to arrange your stay in the Netherlands?
- ❍ Yes (1)
- ❍ No (2)

Answer If Are you an international PhD Candidate? yes Is Selected Or Did you receive any formal or informal support from Leiden University to arrange your stay in the Netherlands? Yes Is Selected

Q33 Which Leiden University staff member(s) or department(s) supported you arranging your stay in the Netherlands? (multiple answers possible)
- ❑ International office (1)
- ❑ My PhD supervisor (2)
- ❑ Colleague(s) (3)
- ❑ Human Resources Department (4)
- ❑ Representatives of my department, institute or faculty (5)
- ❑ other (6)

Answer If Are you an international PhD Candidate? yes Is Selected Or Did you receive any formal or informal support from Leiden University to arrange your stay in the Netherlands? Yes Is Selected

Q36 How satisfied are you in general with the support you were offered?
- ❍ Very Satisfied (1)
- ❍ Satisfied (2)
- ❍ Neither dissatisfied nor satisfied (3)
- ❍ Dissatisfied (4)
- ❍ Very Dissatisfied (5)

Answer If Did you receive any formal or informal support from Leiden University to arrange your stay in the Netherlands? No Is Selected

Q37 You have indicated that you did not receive any support from Leiden University in arranging your stay in the Netherlands. What is the reason for this?
- ❍ Support was offered, but I did not need it. (1)
- ❍ No support was offered and I did not need it. (2)
- ❍ No support was offered, nor did I know it was possible to ask for it. (3)
- ❍ other (4)

Answer If Are you an international PhD Candidate? yes Is Selected

Q38 Are you currently taking or have taken a Dutch language course?
- ❍ Yes (1)
- ❍ No (2)

Answer If Are you currently taking or have taken a Dutch language course? No Is Selected

Q39 Would you like to take a Dutch language course?
- ❍ Yes (1)
- ❍ No (2)

Q41 IV. SUPERVISION This section concerns the supervision you are receiving during your PhD project.

Q42 Training and Supervision Plan (Opleidings- en Begeleidingsplan) At the start of the programme every PhD Candidate must draw up a Training and Supervision Plan with his/her PhD supervisor. At the very least, this plan includes the agreements you and your PhD supervisor make about your research tasks, about the nature and frequency of the supervision you receive from your supervisor, and about the training you receive as part of your PhD project. Are you familiar with the Training and Supervision Plan?
- ❍ Yes (1)
- ❍ No (2)

Q43 Was a Training and Supervision Plan drawn up at the start of your PhD project?
- ❍ Yes (1)
- ❍ No (2)
- ❍ One is being drafted (3)

Answer If Was a Training and Supervision Plan drawn up at the start of your PhD project? No Is Not Selected

Q44 When was the Training and Supervision Plan drawn up?
- ❍ At the same time as I signed the employment contract (1)
- ❍ Within 3 months after I signed the employment contract (2)
- ❍ Within 6 months after I signed the employment contract (3)
- ❍ More than 6 months after I signed the employment contract (4)

Answer If Was a Training and Supervision Plan drawn up at the start of your PhD project? Yes Is Selected

Q45 How often is this plan discussed?
- ❍ Not at all (1)
- ❍ Less than once year (2)
- ❍ Once a year (3)
- ❍ More often than once a year (4)

Answer If Was a Training and Supervision Plan drawn up at the start of your PhD project? Yes Is Selected

Q46 Were the agreements in the Training and Supervision Plan kept?
- ❍ Not at all (1)
- ❍ Most have not (2)
- ❍ Some have, some have not (3)
- ❍ Most have (4)
- ❍ All have (5)

Answer If Was a Training and Supervision Plan drawn up at the start of your PhD project? Yes Is Selected

Q47 To what extent do you agree with the following statement "The Training and Supervision Plan contributes to the smooth execution of my PhD project"?
- ❍ Disagree completely (1)
- ❍ Largely disagree (2)
- ❍ Partly agree/partly disagree (3)
- ❍ Largely agree (4)
- ❍ Agree completely (5)

Answer If To what extent do you agree with the following statement "The Training and Supervision Plan contributes to the smooth execution of my PhD project"? Disagree completely Is Selected Or To what extent do you agree with the following statement "The Training and Supervision Plan contributes to the smooth execution of my PhD project"? Largely disagree Is Selected

Q48 You indicated that you disagree with the previous statement "'The Training and Supervision Plan contributes to the smooth execution of my PhD project?". Would you please shortly explain why?

Q49 Supervision Who is (are) your supervisor(s)? (multiple answers possible).
- ❑ My PhD promotor(s) (1)
- ❑ My co-promotor(s) (2)
- ❑ My daily supervisor(s) (3)
- ❑ My supervision has not been established officially (4)
- ❑ other persons (5)

Answer If Supervision Who is (are) your supervisor(s)? (multiple answers possible). My supervision has not been established officially Is Not Selected

Q50 From whom do you generally receive most of your supervision?
- ❍ My PhD promotor(s) (1)
- ❍ My co-promotor(s) (2)
- ❍ My daily supervisor(s) (3)
- ❍ Other persons (4)

Answer If Supervision Who is (are) your supervisor(s)? (multiple answers possible). My supervision has not been established officially Is Not Selected

Q51 In the following questions the PhD supervisor is to be understood as the person who is most closely involved with assisting you in your research. How often do you and your PhD supervisor meet to discuss your research?

- Daily (1)
- Weekly (2)
- Once every two weeks (3)
- Monthly (4)
- Once every two months (5)
- Once every six months (6)
- I do not have such meetings with my PhD supervisor (7)
- other frequency (8)

Answer If Supervision Who is (are) your supervisor(s)? (multiple answers possible). My supervision has not been established officially Is Not Selected

Q52 How do you rate the frequency of contact with your PhD supervisor?

- Far too low (1)
- Too low (2)
- Exactly right (3)
- Too high (4)
- Far too high (5)

Answer If Supervision Who is (are) your supervisor(s)? (multiple answers possible). My supervision has not been established officially Is Not Selected

Q53 How satisfied are you with the overall quality of supervision from your PhD supervisor?

- Very Satisfied (1)
- Satisfied (2)
- Neither dissatisfied nor satisfied (3)
- Dissatisfied (4)
- Very Dissatisfied (5)

Answer If Supervision Who is (are) your supervisor(s)? (multiple answers possible). My supervision has not been established officially Is Not Selected

Q54 How satisfied are you with the time it takes before your PhD supervisor comments on work you submitted to him or her?

- Very Satisfied (1)
- Satisfied (2)
- Neither dissatisfied nor satisfied (3)
- Dissatisfied (4)
- Very Dissatisfied (5)

Answer If Supervision Who is (are) your supervisor(s)? My supervision has not been established officially Is Not Selected

Q55 How would you rate your PhD supervisor's knowledge regarding the topic of your research?

- Poor (1)
- Mediocre (2)
- Reasonable (3)
- Good (4)
- Very good (5)

Answer If Supervision Who is (are) your supervisor(s)? (multiple answers possible). My supervision has not been established officially Is Not Selected

Q56 Does your PhD supervisor introduce you to his/her academic network?
- ❍ No (1)
- ❍ Yes, but not frequently enough (2)
- ❍ Yes, to a sufficient degree (3)
- ❍ Yes, but too frequently (4)

Q58 V. TEACHING DUTIES As a PhD Candidate you might supervise or teach students. We would like to ask you some questions on this subject.

Q59 Do you have any teaching duties?
- ❍ Yes (1)
- ❍ No (2)
- ❍ I do not know yet (3)

Answer If Do you have any teaching duties? Yes Is Selected

Q60 What kind of teaching duties do you have? (multiple answers possible)
- ❑ Supervising interns/students (1)
- ❑ Supervising Bachelor or Master Thesis (2)
- ❑ Giving lectures (Hoorcolleges) (3)
- ❑ Giving work groups/practicals/seminars (werkcolleges) (4)
- ❑ Other (5)

Answer If Do you have any teaching duties? Yes Is Selected

Q61 Where is the relationship between research and teaching tasks specified? (multiple answers are possible)
- ❑ This relationship is specified in my employment contract (1)
- ❑ This relationship is specified in my Training and Supervision Plan (2)
- ❑ I am only employed for teaching duties. (3)
- ❑ This relationship is not specified at all. (4)
- ❑ Other (5)

Answer If Do you have any teaching duties? Yes Is Selected

Q62 How many hours on average do you have to teach per week THIS semester?

Answer If Do you have any teaching duties? Yes Is Selected

Q63 Who supervises your teaching? (multiple answers possible)
- ❑ PhD supervisor(s) (1)
- ❑ Colleagues (2)
- ❑ Nobody (3)
- ❑ Other person (4)

Q64 The course "Didactics for PhD students and Teaching Assistants" offered by the Leiden University Graduate School of Teaching (ICLON) is a teacher training programme that enables PhD Candidates to obtain their academic teaching credentials. Are you familiar with the course?
- ❍ No, I am not familiar with the course (1)
- ❍ Yes, I am familiar with the course, but I have not taken it (2)
- ❍ Yes, I am familiar with the course and I have taken it (3)

Q66 VI. TIME MAMAGEMENT
This section concerns questions about your expectations with regard to completing your PhD project within the specified period.

Q67 Do you think you will complete your PhD project on time?
- ❍ Yes, I expect to complete it on time (1)
- ❍ No, I do not expect to complete it on time (2)
- ❍ My PhD project already passed the official period. Thus, I will not completed on time. (3)
- ❍ I don't know (4)

Answer If Do you think you will complete your PhD project on time? No, I do not expect to complete it on time Is Selected Or Do you think you will complete your PhD project on time? My PhD project already passed the official period. Thus, I will not completed on time. Is Selected

Q68 You have indicated that you do not think you will complete your PhD project on time or that you failed to do so. Indicate in the matrix below which reasons play a part in this and to what extent.

	no part (1)	small part (2)	significant part (3)	big part (4)
Lack of personal motivation (1)				
The project is too ambitious (2)				
Teaching is at expense of research (3)				
Work-related secondary activities (4)				
Illness (5)				
Pregnancy/Parenthood (6)				
Tricky or insufficiently interesting results (7)				
Insufficient knowledge/skills to carry out research (8)				
Poor relationship with supervisor or supervisors (9)				
Quantity of supervision (10)				
Quality of supervision (11)				
Period of appointment is too short for this project (12)				
The project is not or not sufficiently structured (13)				
I took too many courses (14)				
Wasted much time on meeting requirements of reviewers and editors (15)				
Technical problems (16)				
Relocation of workplace or laboratory (17)				
Experiencing writing difficulties (18)				
Writing in another language causes problems (19)				

Q69 How would you describe the work pressure in your PhD project?
- ❍ Too high (1)
- ❍ High (2)
- ❍ Normal (3)
- ❍ Low (4)
- ❍ Too low (5)

Q70 How often do you feel stressed at work?
- ❍ Always (1)
- ❍ Very often (2)
- ❍ Often (3)
- ❍ Sometimes (4)
- ❍ Never (5)

Answer If How often do you feel stressed at work? Never Is Not Selected

Q71 If you are stressed at work what would you say is the cause for this stress? (multiple answers are possible).
- ❑ Pressure to publish (1)
- ❑ Deadlines (2)
- ❑ Contact with managers/supervisors (3)
- ❑ Contact with colleagues (4)
- ❑ Contact with students (5)
- ❑ Equipment you use (6)
- ❑ Drastic work-related events (7)
- ❑ Drastic events related to personal life (8)
- ❑ Amount of work (9)
- ❑ Difficulty of work (10)
- ❑ Work speed (11)
- ❑ Teaching duties (12)
- ❑ Other activities (13)
- ❑ Work content (14)
- ❑ Interruptions during work (15)
- ❑ Other sources of stress (16)

Q73 VII. Future Prospects and Career Plans In this section we would like to ask you some questions about your plans after finishing your PhD.

Q74 Would you like to stay in academia/research after the completion of your PhD?
- ❍ Yes (1)
- ❍ No (2)
- ❍ I do not know (3)

Answer If Would you like to stay in academia/research after the completion of your PhD? Yes Is Selected

Q75 You have indicated that you would like to stay in academia/research. How do you estimate your chances in finding employment in your field?
- ❍ Very difficult (1)
- ❍ Difficult (2)
- ❍ Neither difficult nor easy (3)
- ❍ Easy (4)
- ❍ Very easy (5)

Answer If Would you like to stay in academia/research after the completion of your PhD? Yes Is Selected

Q76 What kind of job opportunities are you looking for? (multiple answers possible)
❑ a teaching/research position at Leiden university (1)
❑ teaching/research position at another university in The Netherlands (2)
❑ a teaching/research position at a university abroad (3)
❑ a research position at an independent research institute (4)
❑ Other (5)

Answer If Would you like to stay in academia/research after the completion of your PhD? No Is Selected

Q77 You have indicated that you do not want to stay in academia/research after completing your PhD. What is/are the reason(s) for leaving the university/research? (multiple answers possible)
❑ Lack of career perspective (1)
❑ Desire for a career change (2)
❑ Other (3)

Answer If Would you like to stay in academia/research after the completion of your PhD? No Is Selected

Q78 How difficult do you think it will be to find employment outside of academia/research?
❍ Very difficult (1)
❍ Difficult (2)
❍ Neither difficult nor easy (3)
❍ Easy (4)
❍ Very easy (5)

Answer If Would you like to stay in academia/research after the completion of your PhD? No Is Selected

Q79 In what kind of work environment would you like to find employment? (multiple answers possible)
❑ Civil service/government (1)
❑ Teaching (2)
❑ Business (3)
❑ Consultancy (4)
❑ Non-profit sector (5)
❑ Other (6)

Q80 Are you familiar with the career counseling offered by Leiden University?
❍ Yes (1)
❍ No (2)

Answer If Are you familiar with the career counseling offered by Leiden University? Yes Is Selected

Q81 Have you ever used any of the career counseling facilities offered by Leiden University?
❍ Yes (1)
❍ No (2)

Q82 Do you think Leiden University offers sufficient opportunities for career counseling?
❍ Yes, they offer sufficient opportunities. (1)
❍ No, they offer insufficient opportunities. (2)

Q83 If you have any suggestions for improving career counseling for PhD Candidates please leave a comment here.

Q84 VIII. PHD ORGANISATIONS

Q85 Are you familiar with LEO (PhD association at Leiden University - in Dutch: Leids Promovendi Overleg)?
- ❍ Yes (1)
- ❍ No (2)

Answer If Are you familiar with LEO (PhD association at Leiden University - in Dutch: Leids Promovendi Overleg)? Yes Is Selected

Q86 You have indicated that you are familiar with LEO. Did you ever participate in one of the LEO´s activities? (multiple answers possible)
- ❑ I did not attend any of the events (1)
- ❑ PhDrinks (2)
- ❑ Movie Night (3)
- ❑ Museum Night (4)
- ❑ Boat Trip (5)
- ❑ Party (6)
- ❑ Printers fair (7)
- ❑ Other social events (8)

Answer If You have indicated that you are familiar with LEO. Did you ever participate in one of the LEO´s activities? (multiple answers possible) I did not attend any of the events Is Selected

Q87 You indicated that although you are familiar with LEO you have never attended one of our activities. Could you please indicate the reason(s) for this? (multiple answers possible)
- ❑ I am not interested in getting involved with LEO (1)
- ❑ The activities are not interesting (2)
- ❑ I did not have the time (3)
- ❑ Other (4)

Q89 Now we would like to ask you a few questions about the representation of PhD Candidates within the University Council. Are you familiar with the University Council (Dutch: Universiteitsraad)?
- ❍ Yes (1)
- ❍ No (2)

Answer If Now we would like to ask you a few questions about the representation of PhD Candidates within the University Council. Are you familiar with the University Council (Dutch: Universiteitsraad)? Yes Is Selected

Q90 You indicated that you are familiar with the University Council. Do you know about the PhD representation in the Council?
- ❍ Yes (1)
- ❍ No (2)

Q91 If there are any issues that you think need to be addressed in the Council you can leave a remark here.

Answer If Are you familiar with LEO (PhD association at Leiden University - in Dutch: Leids Promovendi Overleg)? No Is Selected

Q88 You have indicated that you are not familiar with LEO. If you would you like to receive information about LEO you can leave your email address here, send us an email (leoleiden.info@gmail.com) or join our facebook group. Otherwise please just go to the next question.

Q92 Most faculties, research institutes and departments have their own council of PhD representatives (in Dutch Promovendiraad). Do you know about the council of PhD representatives at your faculty, research institute or department?
- Yes (1)
- No (2)

Answer If Most faculties, research institutes and departments have their own council of PhD representatives (in Dutch Promovendiraad). Do you know about the council of PhD representatives at your faculty, research institute or department? Yes Is Selected

Q93 Are you satisfied with the PhD Council of your faculty, institute or department?
- Very Satisfied (1)
- Satisfied (2)
- Neither dissatisfied nor satisfied (3)
- Dissatisfied (4)
- Very Dissatisfied (5)

Q94 END You have now come to the end of the survey. Thank you very much for your help! We truly appreciate your support and the time you invested in answering this survey! We hope to use these results to improve the PhD experience at Leiden University.

Q95 If you would like to make any additional comments in response to this survey please use the space below.

Q96 If you would like to receive the report on the results of this survey please enter your email address below.

Q102 Please leave your email address here if you want to take part in our raffle for a 20E, 30E and 50E VVV Cadeaubon - a voucher that can be used to shop at many shops in Leiden and other cities in the Netherlands!