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Gender differences in higher education from a life course perspective: transitions and social inequality between enrolment and first post-doc position

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Abstract In the last decades, a vast number of post-industrialised economies have experienced a growing participation of women in higher education. However, men and women still differ with regard to their subsequent academic careers and labour market prospects. While several studies have disentangled the cumulative process of gender inequalities along the path to higher education, few studies cover two or more subsequent transitions in the academic career following graduation from upper-secondary education. We have investigated gender differences at five educational stages between graduation from upper-secondary education and the first post-doc position. To explain gender differences, we have integrated arguments of individual decision-making and educational, familial and work context conditions. This life course perspective leads us to propose several hypotheses on why the academic careers of men and women would differ in terms of transitions to the next education stage and graduation. We test our hypotheses using a longitudinal dataset which covers a large part of individual educational and academic careers of a cohort of students, beginning at the age of 20 years and extending up to the age of 40 years. Our results show that gender differences are more pronounced at the beginning of the academic career and tend to fade out at later stages. In particular, gender differences occur most strongly at transitions to the next educational stage rather than being caused by different graduation rates. These differences can be explained only to a very minor extent by performance. Separated analysis shows that men and women differ in their reasons to start or stop an academic career, with family circumstances in particular having different consequences.

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Introduction

In the last decades, a vast number of post-industrialised economies have experienced a growing participation of women in higher education. Compared to previous generations, in most countries the present generation of women more often enrol in and graduate from universities (e.g. Buchmann et al. 2008; Chang 2017; Contini et al. 2017; Klevan et al. 2016). Germany complies with this general worldwide trend, although to a comparatively lesser extent (Hauschildt et al. 2015). In Germany, more women than men graduate from upper secondary education and have higher achievement levels. However, men and women still differ with regard to their subsequent academic careers and labour market prospects (e.g. Bobbitt-Zeher 2007; Crabb and Ekberg 2014; Fritsch 2016). Particularly in Germany, women less often use their option to attain higher levels of education, are underrepresented in doctoral programmes and less often reach a full professorship (Federal Statistical Office 2014). This is not without consequences as higher levels of education are associated with higher educational returns, such as integration into the labour market and adequate employment or income (Recotillet 2007; Hout 2012). Thus, gender differences in academic careers partially account for the withstanding gender pay gap among higher education graduates (Leuze and Strauß 2014; Ochsenfeld 2014).

The phenomenon of shrinking female participation at higher-level academic career positions has been labelled with the catchy metaphor of a 'leaky pipeline' (European Commission 2008: 16).[1] While the proportion of women at the outset of the academic career path is relatively high (e.g. at the point of enrolling in higher education), a much smaller proportion of women obtain post-doc positions or full professorships. Several studies have disentangled the cumulative process of gender inequalities along the path to higher education (Breen et al. 2010; Becker and Müller 2011; Lörz et al. 2011), but only a few cover two or more subsequent transitions in the academic career following graduation from upper-secondary education (e.g. Leemann et al. 2010; Chang 2017). With particular reference to Germany, a number of studies have described parts of the academic pipeline and provided valuable insights on the existence, size and underlying reasons for these 'leaks'. Auspurg and Hinz (2011) observed the transition from bachelor's to master's degrees, Leemann (2002) focussed on the period between higher education and doctoral studies and two other groups analysed the time after having obtained a doctoral degree (Schubert and Engelage 2011) or a 'habilitation' (Jungbauer-Gans and Gross 2013). To the best of our knowledge, no study on German higher education covers gender differences from the very start of higher education to post-doc positions or professorship.[2]

To summarize, these studies indicate that in Germany gender differences mostly emerge before the completion of a doctorate. Thereafter, the 'pipeline' seems to be pretty tight, and the disadvantages of the small group of women who make it further up the academic ladder seem to be negligible if not reversed (Schubert and Engelage 2011; Jungbauer-Gans and Gross 2013); Webber and Gonzalez Canché (2018) report similar results for the USA. However, the

[1] This simplification of gender inequality processes has been criticised by Allen and Castleman (2001).
[2] There are comparative studies and studies on other countries (e.g. Bagilhole and White 2013; Silander et al. 2013; Morley 2016) but studies analysing the trajectories of an individual cohort over a long period are generally scarce.

following questions are pending: (1) At which transitional stage(s) in the academic career path do gender differences emerge? (2) What is the relative size of these gender differences; i.e., which transitions are more salient? (3) Do the mechanisms leading to drop-out differ between women and men and between transitions? In the study reported here, we tackled these research questions using a longitudinal panel dataset covering the time from leaving school and obtaining a higher education entrance qualification to the first post-doc position.

Excursus: the German context

The German education system is strongly stratified. In secondary education children are tracked early (mostly at the age of 10 years) into three types of schools offering education at different levels. Only the *Gymnasium* directly leads to higher education; the two other types of schools (*Hauptschule*, *Realschule*) prepare the student for vocational education. If graduates of these latter two schools qualify for higher education at later stages, they may often be granted entrance to a higher education facility, but it is restricted to universities of applied sciences. Germany has a binary higher education system with traditional universities and more practically oriented universities of applied sciences. The latter can award doctoral degrees only in cooperation with universities. Thus, the path for (or against) an academic career is set early, and social differences in secondary education are carried forward to higher education and beyond. Higher education was opened for persons with vocational qualifications in 2009, but for the cohort of our study (1990 school leavers), the conditions were still quite restrictive. Path dependencies are reinforced by the high standards of the dual vocational education in Germany offering relatively safe employment prospects.

Doctoral studies in Germany have become more structured in recent years, notably by a growth in graduate schools. When the school leavers of 1990 graduated from higher education, access to the doctorate was nearly exclusively steered by professors. The importance of informal relationships might have preserved existing gender disproportionalities among doctoral students, especially in subjects and faculties with very low proportions of female students (Cain and Leahey 2014). Attaining a professorship at a German university typically requires a post-doctoral thesis (*Habilitation*). Since 2002, tenure-track positions (*Juniorprofessur*) have been established to some degree, and publications equivalent to a post-doctoral thesis are increasingly accepted. However, the requirement of a *Habilitation* further prolongs the insecurity of academic careers in many cases.

Germany is the prototype of a conservative welfare state (Esping-Andersen 1990) committed to traditional familyhood values. Tax splitting for married couples incentivizes an unequal distribution of paid work and income, and the linking of social insurance benefits to previous incomes additionally rewards full-time employment. Compared to other developed countries, daycare services are comparatively less developed, especially in the western part of Germany. Although there have been recent policy changes, such as financial support for parental leave with an incentive for both partners to share the time off (2007) or an expansion of child care provisions (2013), these changes will no longer strongly affect the cohort of 1990 of this study.

In summary, the German educational and welfare state institutions are more suited to reinforce and preserve gender differences in academic careers than to diminish them.

Theoretical considerations

Educational attainment is often viewed as the result of an individual, sequential and multistage decision-making process (Mare 1980). Especially with regard to social inequality, many studies have found empirical evidence for this decision-focused perspective, tracing back educational differences to expectations of costs, benefits and success probabilities (Stocké 2007). Rational-choice theory and its extensions seem to be the most suitable approach for modelling individual decisions. However, individuals do not make decisions independently from their context. Life course theory hints at the various spheres of life (including the past) being important contexts for explaining individual trajectories (Elder et al. 2003). The critical mass theory highlights the gender composition of social groups for explaining gender differences in (scientific) careers (Kanter 1977; Etzkowitz et al. 1994). With this background, we understand an academic career to be the cumulative result of individual decision-making processes (section 3.1) under varying context conditions (section 3.2). As stages of the academic career we consider the following five steps that most students in Germany must take to reach a post-doc position[3]:

1. Transition 1: enrol in higher education,
2. Graduation 1: complete higher education,
3. Transition 2: start a doctoral programme,
4. Graduation 2: complete the doctorate,
5. Transition 3: start the first post-doc position.

Decision-making

In rational choice theory, individuals choose the educational alternative with the highest expected utility regarding the expected costs, benefits and success probabilities (Erikson and Jonsson 1996). Expectations of success probabilities are likely to depend on, firstly, previous performance in education (Jonsson 1999). Expected benefits and (opportunity) costs of an educational career and alternatives should be related to, secondly, the motivations and orientations of individuals. However, how do these factors influence the decisions of women and men in choosing for or against continuing an academic career?

Performance

From a meritocratic point of view, good performance should foster starting and continuing an academic career (Plümper and Schimmelfennig 2007). Firstly, students with better grades more often manage to overcome admission restrictions. Secondly, good grades are strongly related to factors like intelligence and diligence (Rindermann and Neubauer 2001), which are likely to be advantageous qualities in higher education. Thirdly, previous good performance may well form expectations on future performance and increase subjectively perceived success probabilities.

[3] In the following analysis we do not distinguish between bachelor's and master's degrees, because these degrees where not introduced before 2002 in Germany.

Compared to male studies, female students attain higher competence levels in secondary education in Germany (Stanat and Kunter 2001) and complete their upper secondary education with better final grades (Lörz et al. 2011). In the USA, the better grades of female students have been shown to translate into higher enrolment rates among women (Klevan et al. 2016). In Germany, these differences seem to level off during the course of higher education. Men have been shown to have better doctoral grades (Fabian et al. 2013) and are more productive in terms of publications (Jaksztat 2017). Similarly, van den Besselaar and Sandström (2016) found for the Netherlands that male researchers showed higher productivity levels—although only at later steps of their academic career. Furthermore, men and women differ in the perception of their own performance. Women tend to assess their abilities more pessimistically (or men more optimistically), a tendency which influences career-relevant decisions (Correll 2001; Lörz et al. 2011). Generally, we expect that higher performance increases the likelihood of choosing an academic career (*transitions*) and of being successful at all educational stages (*graduations*). The positively skewed expectations of men could mitigate the performance advantages of women at the start of the academic career (*transition 1*). At later stages (*transitions 2 and 3*), these positive subjective assessments would even contribute to the better performance of men. Therefore, we expect performance in particular to explain the drop-out of women in advanced academic careers.

Motivations and orientations

In line with rational choice theory, Lörz et al. (2011) argue that men and women vary in their expected costs and benefits of educational choices due to motivations and orientations. Socialisation theories trace back such differences to early childhood at which time traditional gender roles and societal expectations are conveyed, leading to gender-specific interests and life-plans (Charles and Bradley 2002). While traditional gender roles fade in most Western societies (Knight and Brinton 2017), in some countries they still have a strong impact on educational participation (Cattaneo et al. 2017). With regard to the situation in Germany, we assume that gender roles still have an effect on women's and men's motivations and orientations.

As a result of traditional gender roles men more often strive for occupations with good career prospects and high earnings (extrinsic motivations; Davies and Guppy 1997; Bradley 2000). Extrinsic motivations increase the subjective benefits of higher education and a doctoral degree (*transitions 1 and 2*) as both expand the bandwidth of job opportunities and are often a prerequisite for high occupational positions (Spangenberg et al. 2012; Mertens and Röbken 2013). Thus, men are more often expected to start higher education and a doctoral programme than their female counterparts, partially due to the former's higher extrinsic motivations. The relationship is less straightforward for the transition to a post-doc position because in some fields of study (i.e. engineering) career prospects are better in the private sector (*transition 3*).

Because of traditional gender roles we expect women to have stronger family orientations than men. These orientations should result in the choice of enrolling in higher education being less attractive to women (*transition 1*). Studying often requires geographic mobility, postpones labour market integration and thus typically postpones starting a family as well (Schaeper et al. 2016). Similarly, a doctoral programme prolongs the period of insecure employment and is likely to delay starting a family (*transition 2*; Mills et al. 2011). However, to the extent that traditional gender roles are at stake, the rationales of women and men might differ at this stage: high family orientations should more strongly deter men from a doctoral programme as it

conflicts with being responsible for supporting a family; for women, this would be less the case. In contrast, women might see the flexible working arrangements of a doctoral programme as fitting in relatively smoothly with family responsibilities. Moreover, it seems plausible to expect gender-specific effects on *graduations*. Women with strong family orientations are more likely to interrupt their studies to start a family. Men with strong family orientations could be specifically motivated to graduate successfully and earn a living.

Intrinsic motivation is a key factor for an academic career and means that people are motivated to study a certain subject for its own sake (Ryan and Deci 2000). However, in our analysis we consider intrinsic motivation to be a control variable because we do not expect gender differences.

Individuals consider direct and indirect (opportunity) costs when deciding to start an academic career. Generally, students with higher cost sensitivity are less likely to enrol in higher education and to continue with a doctoral programme. Gender differences in this regard are less clear. On the one hand, women have been found to be more sensitive to (direct) educational costs (Lörz et al. 2011); on the other hand, men could be specifically sensitive to (indirect) opportunity costs. In line with their traditional role as the family's breadwinner, the latter might attach more value to the immediate and relatively safe income prospects of vocational training and associated jobs.

Context conditions

From a life course perspective, individual educational choices depend on context conditions (Elder et al. 2003; Pallas 2003). Elder et al. (2003) argue that individuals have "multiple roles simultaneously"; for example, they have roles in education, work and family, while at the same time being influenced by previous experiences and the historical context. As a consequence (1) the educational context, (2) the employment context and (3) the family context should be considered when analysing individual educational and occupational careers.

Educational context

The educational context includes previous experiences, present opportunities and future returns. Persons are likely to evaluate the alternatives of higher education and vocational education differently, depending on whether they already have a vocational qualification. Individuals with a vocational qualification often will have decided to obtain a higher education entrance qualification for the very reason of being able to study. From a human capital perspective (Becker 1964), further investment in vocational training will thus not make much sense (*transition 1*). At the same time, graduates with double qualifications are older, and it is less clear whether further educational investment in a doctoral degree will reap financial benefits in the working time remaining. Thus, such individuals are less likely to start a doctoral programme (*transition 2*). More men than women have completed a vocational qualification before studying (Spangenberg et al. 2012), making the former more likely to access higher education and less likely to start on a doctoral programme.

The type of upper-secondary education is related to different educational opportunities. In Germany, two paths of secondary education lead to higher education: (1) general schools award the *Abitur*, a general higher education entrance qualification for any type

of institution; (2) vocational schools provide more practical education and award the *Fachhochschulreife*, a restricted qualification certificate, giving access to universities of applied sciences. Graduates of general schools have all options, and accessing higher education is the most straightforward next step (*transition 1*). These individuals more often opt for traditional universities, while students from vocational schools tend to choose universities of applied sciences (Reimer and Pollak 2010). Only traditional universities award a doctorate. As the type of school is linked to the type of higher education institution, it is plausible to assume that graduates of general schools are more likely to start a doctoral programme, and, consequently, attain a post-doc position (*transitions 2 and 3*). Expectations are less straightforward with regard to *graduation*: on the one hand, students from general schools may be better prepared for successfully completing higher education; on the other hand, traditional universities have higher drop-out rates (Isleib and Heublein 2017). Women more often graduate from general schools, and thus they have an educational context beneficial for studying at a traditional university and to continue with a doctoral degree. Similarly, in Italy male students more often attend vocational and technical secondary schools, which has been found to explain why they are less likely to access higher education and more likely to drop out of higher education programmes (Contini et al. 2017).

The field of study could influence gender differences in educational trajectories in a variety of ways. While drop-out rates are somewhat higher in male-dominated subjects, such as science and engineering, they are lower in female-dominated fields, such as languages and the social sciences. One could therefore expect that men complete higher education less often than women due to differences in the choice of field of study (*graduations*). In some fields, a doctoral degree is more important for success in the labour market; for example, medicine or science. However, due to the overall allocation of men and women across these disciplines, we expect no major gender effect in the field of study on the transition to a doctoral programme or a post-doc position (*transitions 2 and 3*). Last but not least, the gender composition within fields of study could be relevant. In fields with a very low proportion of female or male students, respectively, these students may be regarded as "tokens" (Kanter 1977), which could impede their academic career by, for example, an excess of attention, a distorted perception of performance or little support by the faculty staff (Etzkowitz et al. 1994). Accordingly, Howe-Walsh and Turnbull (2016) identify male-dominated networks as one of the main barriers to be overcome by women navigating their academic career in science and technology. An extremely skewed gender composition can be noted in the fields of engineering and the humanities which could in turn negatively affect the graduations and transitions of women and men.

Employment context

Being an employee is another role people may have next to being a learner and a family member. Jobs as a student assistant or researcher are presumably advantageous to successful graduation. At the same time, working reduces the time available for studying. We assume that particularly high volumes of work generally impair *graduation*. Fabian et al. (2013) found that male doctoral students work more often as researchers than female doctoral students. Therefore, we expect that the overall negative effect of high volumes of work on attaining a doctorate should be smaller for men (*graduation 2*).

Family context

The family as an institution is crucial for differences in the life course of women and men, and it has long been neglected in life course research (Busch 2013). Starting a family is likely to have different consequences for women and men. In the sense of traditional roles, for men, starting a family is not in conflict with leading a life centred on employment and often does not even interrupt employment. With regard to the academic career, the requirement to support the family may in fact deter men from beginning a study or starting an academic career as it goes together with opportunity costs and less clear career perspectives. Similarly, we expect women to be less likely to start and more likely to stop an academic career if they bear children due to motherhood and family responsibilities. Thus, we expect similar consequences for different reasons. Men seem to be more likely to forego an academic career and choose for quicker and safer employment, while women seem to more likely to take family responsibilities instead. Higher education or a doctoral programme offers relatively flexible working hours and could be more easily combined with family responsibilities. We assume that the negative effect of becoming a parent is stronger for men than for women (*transitions*). Bearing a child during the course of a study or during a doctoral programme is likely to have a generally negative effect on graduation. Due to motherhood and a disproportionate allocation of caring work (Middendorff 2008), the negative impact should be stronger for women (*graduations*). Similarly, results of Castello et al. (2017) suggest that Spanish female students with family commitments had more problems accommodating the obligations of their doctoral programme than those without.

Table 1 gives an overview of our hypotheses regarding the effect of each respective factor on gender differences: '♂' indicates that the considered aspect boosts the participation of men; '♀' indicates that the considered aspect fosters the participation of women. Note that Table 1 focusses on effects due to the different distribution of characteristics across both sexes. As discussed above, we additionally expect gender-specific effects of the factors family orientations, birth of child, employment and field of study (engineering) which is displayed in Table 1 with and asterisk.

Table 1 Overview of hypotheses presented in this paper

Characteristics	Higher education		Doctoral programme		Post-doc-position
	Transition	Graduation	Transition	Graduation	Transition
Performance	♀	♀	♂	♂	♂
Motivation					
Extrinsic motivation	♂		♂		
Cost sensitivity					
Intrinsic motivation					
Family orientation	♂		♂		♂
Education					
Prior vocational education	♂		♀		
General school	♀	♀	♀		♀
Field of study		♀/*	*	*	*
Volume of work				*	
Birth of child	*	*	*	*	

♂', Increases participation of men; ♀, increases participation of women; *, effects differ between men and women

Data, variables and methods

Data

We apply data compiled in the Panel Study of School Leavers with a Higher Education Entrance Qualification of the German Centre for Higher Education Research and Science Studies (DZHW). This study has been carried out at regular intervals since 1976. It provides representative data on the educational and professional histories, motivations and life goals of German graduates of upper-secondary education with a higher education entrance qualification. The analysed cohort graduated in 1990 and was interviewed by standardised mail surveys at 6 months (first wave), 3.5 years (second wave), 5.5 years (third wave), and 20 years (fourth wave) after graduating from upper-secondary education. The first wave of December 1990 consists of a sample of 23,990 cases (response rate 35%). Due to panel attrition over three follow-up surveys, the fourth wave of December 2010 consists of a sample of 7019 cases (see Table 5 in Appendix). Cases with missing information were excluded from our analysis, resulting in an analytical sample of 6646 valid cases. The data were weighted by sex, type of school, type of upper secondary degree and region to control for sampling bias.

Variables

As noted in the theoretical considerations, we investigated five different *dependent variables*, as represented by the following five steps of the academic career:

1. Transition 1: enrol in higher education,
2. Graduation 1: complete higher education,
3. Transition 2: start a doctoral programme,[4]
4. Graduation 2: complete the doctorate,
5. Transition 3: start the first post-doc position.

These sequential and selective steps are illustrated in Fig. 1 for all respondents (Fig. 1a) and for men (Fig. 1b) and women (Fig. 1c) separately. Generally, *transitions* lead to more persons leaving the academic career path than *graduations*. Apart from this similarity, however, there are remarkable differences in the educational and occupational careers of women and men. After graduating from upper-secondary education, men more often enrol in higher education than women (85% vs. 70%) and more often start a doctoral programme (19% vs. 16%). Moreover, men slightly more often complete higher education (94% vs. 92%) and the doctorate programme (82% vs. 80%). As a result of cumulative selections, only between 1% (female) and 2% (male) of the school leavers with a higher education entrance qualification achieve a post-doc position.[5]

The means of the independent variables and the mean values of gender differences are given in Table 2 . Gender is the focal independent variable. All other independent variables are applied to explain gender inequalities in the academic career path. For most independent

[4] From the third step onwards, graduates of universities of applied sciences are excluded from the analyses as the small number of doctoral students from this type of institutions does not allow differentiated analyses.

[5] Post-doc position includes all scientific research positions at a traditional university or university of applied sciences (i.e. academic staff, junior professor, assistant professor, full professor).

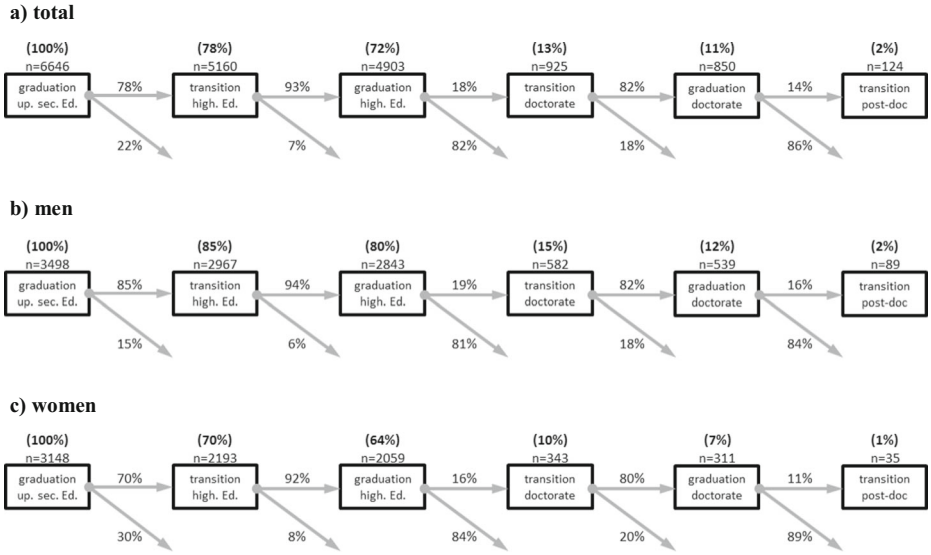

Fig. 1 Participation in higher education by gender (in percentage)

variables, men and women differ significantly in their mean values, revealing a certain explanatory potential.

Performance is captured by the final grade for the respective level of education, i.e. at the upper-secondary education level, higher education level and doctorate. For these analyses, grades have been recoded so that higher numbers imply better grades. Grades were also standardised by field of study to reflect differences in the mean level of grades. In the study cohort, women have slightly better grades in upper-secondary education (the difference is not significant), while men have significantly better grades at the doctoral level (Fig. 2).

Motivations are measured in wave 1. Respondents could express the importance of different reasons for choosing their education on a 6-point scale ranging from 0 (not important at all) to 5 (highly important). Extrinsic motivation is measured by the relevance of 'acquiring a good reputation and high professional prestige'. The relevance of 'financial independence' is used as an indication for cost sensitivity. Intrinsic motivation is measured by the 'interest in scientific work' (this includes all academic disciplines—not only the sciences). In this analysis we consider the relevance of 'local bonds'. As expected, men show stronger extrinsic motivations which could be beneficial for an academic career. In contrast to our assumptions, women do not have higher cost sensitivity or higher local bonds. In fact, men tend to support all motivations more strongly, but differences are largest for extrinsic motivations and smallest for local bonds.

The educational biography is covered by the type of upper-secondary school (general vs. vocational), vocational training (binary) and field of study. Women more often studied in general schools and more often choose medicine which often leads to a doctoral degree. In contrast, men more often complete vocational training before attaining a higher education entrance qualification and more often choose science or engineering. These differences are associated with educational opportunities; for example, medical and science students more often do a doctorate than students of humanities or engineering.

Table 2 Independent variables

Independent variables	Mean values			
	Total respondents	Male	Female	Significance[a]
Performance				
School grade (z-scores, −2.8 to 1.8)	0.00	− 0.03	0.03	n.s.
Study grade (z-scores, −4.2 to 2.2)	0.00	0.02	− 0.02	n.s.
Doctorate grade (z-scores, −4.3 to 1.6)	0.00	0.13	− 0.23	***
Motivations				
Professional prestige (6-point scale)	0.00	0.21	− 0.21	***
Financial independence (6-point scale)	0.00	0.15	− 0.15	***
Scientific work (6-point scale)	0.00	0.13	− 0.14	***
Local bonds (6-point scale)	0.00	0.05	− 0.05	***
Educational biography				
Type of school: (0: vocational, 1: general)	0.69	0.65	0.74	***
Prior vocational training in 1990: (0: no, 1: yes)	0.22	0.29	0.14	***
Field of study:				
-Science	0.16	0.18	0.14	***
-Engineering	0.26	0.36	0.12	***
-Medicine	0.07	0.06	0.09	***
-Economics/law	0.23	0.26	0.19	***
-Humanities	0.27	0.14	0.45	***
Work circumstances				
Proportion of months worked during study	0.13	0.13	0.14	n.s.
Family commitments				
Birth of child in 1990 (0: no, 1: yes)	0.02	0.02	0.02	n.s.
Control variables				
Social background (0: non-academic, 1: academic)	0.37	0.36	0.39	**
Age (years) in 1990 (18, minimum to 30, maximum)	20.0	20.3	19.8	***
Region in 1990 (0: east, 1: west)	0.89	0.90	0.88	***

Data source: Panel Study of School Leavers with a Higher Education Entrance Qualification of the German Centre for Higher Education Research and Science Studies (DZHW) 1990 (fourth wave)

[a] Significant differences between men and women: n.s., Not significant); *, **, ***, significant difference between men and women at $p < 0.05$; $p < 0.01$; and $p < 0.001$, respectively

Work circumstances are captured by the length of time doing paid work (employed or self-employed) up to each respective transition. This information was derived from a calendar in which respondents reported on their activities in the 20 years since having left upper-secondary

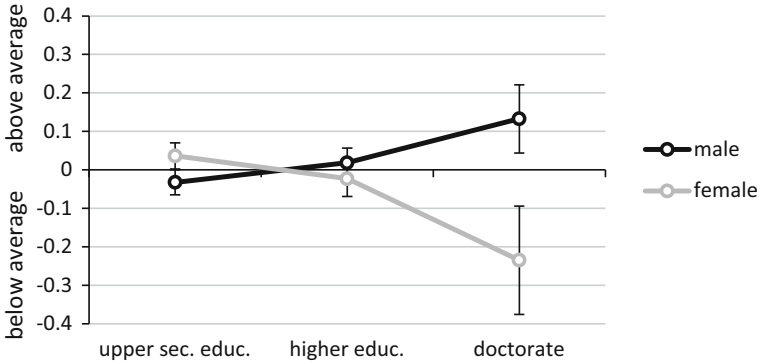

Fig. 2 Performance in higher education by gender (z-standardised)

education. Work circumstances are measured as the proportion of months in paid work in relation to the overall number of months up to the respective transition (0 [zero number of months doing paid work] to 1 [100% of period doing paid work]). Unfortunately, the dataset provides no variable measuring whether a job is related to study topics. Family commitments are measured by the birth of a child (binary) before each respective transition. Table 2 shows the means for the transition to higher education only. In 1990 only a minority of students have had children (2%); however in 2009 the majority have children (67%).

While the individual aspects (performances and motivations) are measured as time-constant variables, all context conditions (educational, work and family circumstances) vary over time. These time-varying variables are taken into account in the analyses by estimating five different variables for each educational step (i.e. children in the year 1990, 1995, 1997, 2000 and 2007).[6]

Methods

The descriptive statistics in Table 2 show that women and men in fact differ on most aspects considered. Some characteristics could partially explain why men are more likely to start and continue an academic career, while other characteristics seem to be beneficial for women. Thus, potential determinants of gender differences are likely to level each other out and need to be tested simultaneously to determine their effects and explanatory power. In the following section, we therefore apply a twofold analytical strategy at the five educational steps of the academic career presented above. Firstly, we estimate logistic regressions to test which part of the gender differences can be traced back to differences in the explanatory variables. The different educational stages are analysed separately to identify their relative importance for gender differences. We report the effect sizes of coefficients as *average marginal effects* (β_{AME}), which we obtained using the delta method (Bartus 2005). Average marginal effects can be interpreted as a change in the probability to enrol in/graduate from an educational step with a one-unit change in a respective independent variable. These coefficients have the advantage of being comparable between the different regression models (Mood 2010) and can tell us at which educational step gender differences are strongest and which share of the gender differences can be explained by the variables considered (section "At which steps do women leave the academic career and why?"). Secondly, we estimate logistic regressions for men and women separately to identify gender-specific mechanisms in the educational career. Again we report the coefficients as average marginal effects and apply a Chi^2-test (Auspurg and Hinz 2011) to check whether or not the coefficients significantly differ between men and women (section "Do mechanisms differ between women and men?").

Results

At which steps do women leave the academic career and why?

The results of logistic regression models that have been calculated for each transition separately are shown in Table 3. These results are reported stepwise with two models for each

[6] Due to the individual beginning and graduation of every educational step, the measurement time points of these variables differ between respondents.

Table 3 Logistic regressions on the five steps of the academic career (average marginal effects)

Independent variables	Transition 1 (higher education)		Graduation 1 (higher education)		Transition 2 (doctoral programme)		Graduation 2 (doctorate)		Transition 3 (post-doc position)	
	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2
Gender										
Male (vs. female)	0.15***	0.12***	0.02*	0.02**	0.09***	0.05**	0.06*	0.05	0.04	0.05+
Performance										
Final school grade		0.04***		0.04***						
Final exam grade						0.11***		0.06***		
Final doctorate grade										0.09***
Motivations										
Professional prestige		0.00		0.00		0.01+		0.01		− 0.01
Financial independence		− 0.05***		− 0.00		− 0.01*		− 0.00		− 0.00
Scientific work		0.05***		0.00		0.03***		0.01		0.01
Local bonds		− 0.01***		− 0.01**		− 0.01**		− 0.02+		0.01
Educational biography										
Prior training: yes (vs. no)		0.13***		− 0.01		− 0.06**		− 0.05		− 0.03
Type of school: general (vs. vocational)		0.16***		0.02		− 0.05+		0.03		− 0.00
Field of study: (Reference. economics)										
-Science				− 0.01		0.26***		0.09*		− 0.03
-Engineering				0.02+		0.11***		− 0.00		− 0.06
-Medicine				0.00		0.50***		0.11*		0.11+
-Humanities				0.00		− 0.00		− 0.10+		0.18*
Work circumstances										
Volume of work (in percentage)				− 0.05***		0.02		− 0.06*		0.02
Family commitments										
Birth of child: yes (vs. no)		− 0.10*		− 0.06***		− 0.03		− 0.11**		0.01
Control variables										
Academic parents (vs. non-academic)		0.09***		0.02*		0.06***		0.03		0.00
Age		0.00		− 0.00		− 0.00		− 0.00		0.00
Region: West (vs. east)		0.04*		0.02		0.04*		− 0.02		0.01
N	6646	6646	5255	5255	3140	3140	835	835	622	622
Wald-Chi^2	172	835	6	252	27	582	4	74	2	35
Pseudo R^2	0.03	0.23	0.00	0.10	0.01	0.29	0.01	0.13	0.00	0.10

There are two models (1 and 2) for each transition (A, C, E) or graduation (B, D). Model 1 shows the difference between women and men without controls, model 2 is the full model that takes all of the explanatory variables into consideration

Data source: DZHW School Leavers Survey 1990 (fourth wave)

Significance: +$p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

transition (A, C, E) or graduation (B, D). Model 1 shows the difference between women and men without controls, model 2 is the full model that takes all of the explanatory variables discussed above into consideration. Comparison of the gender coefficients of the first and second model reveals the extent to which gender differences are due to the explanatory variables.

The first models confirm that male students more often enrol in higher education (β_{A1} = .0.15) and more often start a doctoral programme (β_{c_1} = 0.09). Men are also somewhat more likely to complete higher education (β_{B1} = 0.02) and to complete a doctorate (β_{D1} = 0.06). Gender differences are not statistically significant for the transition to a post-doc position .

A first conclusion is that gender differences are mainly due to *transitions* between stages of education and to a lesser extent due to different success rates of female and male students within education, i.e., *graduations*. Secondly, in line with Mare's sequential selection model (Mare 1980), earlier transitions are more salient for gender differences than later transitions. Women considerably more often leave the educational system either before having accessed higher education at all or at the very beginning of their academic career, i.e., after having completed higher education but before a doctoral programme. This is in accordance with previous research in Germany in this field that has found no or only small 'leaks' in the later parts of the academic 'pipeline' (Jungbauer-Gans and Gross 2013) where a highly selective group remains.

Which factors can explain the observed gender differences between enrolment and first post-doc position? With regard to the individual decision-making process, our results show that good grades significantly foster the beginning and continuation of an academic career at all educational stages. This finding matches theoretical expectations. Motivational aspects influence the academic career mainly at the transitions. Intrinsic motivations (scientific work) increase the probability of enrolling in higher education (β_{A2} = 0.05) and to start a doctoral programme (β_{C2} = 0.03). High cost sensitivity (financial independence) lowers the probability to enrol in higher education (β_{A2} = − 0.05) and to start a doctoral programme (β_{C2} = − 0.01). Furthermore, in line with hypothesised effects, local bonds lower the probability to begin and continue an academic career. Local bonds (β_{C2} = − 0.01) hinder the continuation of an academic career, especially at the transitions to higher education (β_{A2} = − 0.01) and the doctorate programme. Unexpectedly, an extrinsic orientation (professional prestige) has no (positive) impact on the academic career.

Among the context conditions, the birth of a child significantly lowers the probability of an academic career at the transition to higher education (β_{A2} = − 0.10), graduation from higher education (β_{B2} = − 0.06) and completion of the doctoral programme (β_{D2} = − 0.11). Family commitments are apparently not easily compatible with a career in higher education. The effects of the educational biography differ between transitions: while prior vocational training is positively associated with enrolling in higher education (β_{A2} = 0.13), it is negatively correlated with the start of a doctoral programme (β_{C2} = − 0.06). This finding seems to confirm the notion that a relatively large proportion of those who have completed a vocational training programme achieve a higher education entrance qualification to continue studying but that after having successfully graduated from higher education they are more likely to enter the labour market rather than investing further in education in the form of doctoral studies. As human capital theory suggests, for students with a double qualification it is less clear whether further educational investment in a doctoral degree will pay off in financial terms during the

time remaining for working. Furthermore, the transition and completion of a doctorate varies significantly by field of study. Students in science (β_{C2} =0 .26; β_{D2} = 0.09) and medicine (β_{C2} = 0.50; β_{D2} = 0.11) are more likely to start and successfully graduate from a doctoral program. In Germany, the doctoral level is the common degree in medicine. Also for science, a doctoral degree is more often required in the labour market than for graduates of humanities, economics or engineering. Finally, graduation is strongly affected by the volume of work. Students with a high work load less often complete higher education (β_{B2} = − 0.05) and a doctorate (β_{D2} = − 0.06). All these effects are in line with our theoretical assumptions.

Even though nearly all explanatory factors significantly influence transitions, for most steps in the educational career they jointly explain only a small share of the gender gap. The gender differences in completing an educational level remain nearly unchanged by the variables in the model. This is quite surprising because success in (higher) education should result from meritocratic criteria, such as higher achievement levels, rather than from ascriptive characteristics, such as gender. The gender difference for enrolling in higher education drops by 3 percentage points only (from 15 [β_{A1}] to 12 [β_{A2}] percentage points) which is not a satisfactory reduction, but probably the result of opposing effects that cancel each other out or confounding factors not captured by the model. For the transition to doctoral programmes, about half of the gender difference can be explained by the independent variables (from 9 [β_{C1}] to 5 [β_{C2}] percentage points).

Do mechanisms differ between women and men?

Women and men differ in a variety of characteristics, but the explanation of gender differences in academic career choices based on these factors remains somewhat unsatisfactory. Theoretical considerations led us to suspect that men and women could additionally differ in the ways in which factors influence transitions and graduations towards a post-doc position. Due to traditional gender roles, the birth of a child could foster graduation from higher education and doctoral programs among men but be a hurdle to success among women. Similarly, we assumed that the birth of a child would hinder men more strongly in taking up higher education or doctoral studies. We tested these hypotheses in separate logistic regression models for women and men and also more generally to determine whether mechanisms leading to an academic career differ by gender (Table 4).

In fact, coefficients differ markedly between men and women for several aspects. Men with children less often enrol in higher education than women (− 0.09 vs. 0.03). Women seem to be less affected by these family aspects at the *transition* to the next educational level. However, children have a much stronger negative impact on *graduation* rates of women, be it in higher education (− 0.07 vs. − 0.02) or a doctoral programme (− 0.13 vs. − 0.05; difference not statistically significant). This is in line with our theoretical expectations. However the birth of a child does not affect the completion rates of men in any significant manner. For both women and men, children negatively affect the likelihood of pursuing an academic career—but this effect works at different educational steps. Furthermore, in line with theory, a high volume of work negatively affects the likelihood of completing a doctoral programme for women only (− 0.18 vs. − 0 .01). As discussed above, men at this stage more often work as researchers and benefit from synergies between employed work and writing a doctoral thesis. However, female doctoral graduates with a high volume of work more often reach a post-doc position (0.12 vs. − 0 .03).

The gender composition of the fields of study seems to influence whether individuals pursue an academic career. We expected negative effects in the field of engineering for women

Table 4 Logistic regressions on five steps of the academic career differentiated by gender (average marginal effects)

Independent variables	Transition 1 (higher education)		Graduation 1 (higher education)		Transition 2 (doctoral programme)		Graduation 2 (doctorate)		Transition 3 (post-doc position)	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Performance										
Final school grade	0.05***	0.03***	0.04***	0.04***						
Final exam grade					0.08***	0.14***	0.07*	0.05**		
Final doctorate grade									0.06*	0.12***
Motivations										
Professional prestige	0.00	0.00	0.00	0.00	0.00	0.01*	0.01	0.01	0.01	− 0.02
Financial independence	***− 0.06*******	***− 0.03*******	***0.00***	***− 0.01****	− 0.01+	− 0.01	− 0.02	0.01	− 0.01	− 0.00
Scientific work	0.06***	0.04***	0.01	− 0.00	0.03***	0.03***	0.01	0.01	0.00	0.01
Local bonds	− 0.02***	− 0.01**	− 0.00	− 0.01**	− 0.00	− 0.02**	− 0.03*	− 0.00	− 0.02	0.02+
Educational biography										
Prior training: yes (vs. no)	***0.08****	***0.16*******	− 0.02	0.00	− 0.04	− 0.08*	0.01	− 0.05	0.01	− 0.06
Type of school: general (vs. vocational)	0.17***	0.11***	*− 0.01*	*0.03***	− 0.08**	− 0.04	− 0.01	0.05	− 0.06	0.03
Field of study: (Reference: economics)										
-Science			− 0.02	− 0.00	0.21***	0.24***	0.13	0.08	0.07	− 0.01
-Engineering			0.01	0.02+	0.08	0.12***	− 0.05	− 0.00	− 0.01	− 0.11
-Medicine			− 0.01	0.02	0.36***	0.38***	0.10	0.12+	0.12	0.08
-Humanities			− 0.00	0.01	0.01	0.02	− 0.12	− 0.04	0.09	0.18*
Work circumstances										
Volume of work (*in percent*)			− 0.06***	− 0.06***	− 0.01	0.05	***− 0.18******	***− 0.01***	***0.12****	***− 0.03***
Family commitments										
Birth of child: yes (vs. no)	*0.03*	*− 0.09***	*− 0.07****	*− 0.02*	− 0.02	− 0.04	− 0.13*	− 0.05	− 0.06	0.02
Control variables										
Academic parents (vs. non-academic)	0.10***	0.09***	0.02+	0.01	0.06**	0.07***	0.03	0.04	0.00	− 0.01
Age	***0.03*******	***− 0.02*******	− 0.00	− 0.00	***0.01**+	***− 0.03****	− 0 .02	0.01	− 0.00	0.01
Region: West (vs. east)	***− 0.01***	***0.09*******	0.03+	0.00	***−0.02***	***0.10******	− 0.02	− 0.01	0.04	− 0.01
N	3242	3404	2364	2891	1489	1651	329	506	226	396
Wald-Chi^2	967	463	116	158	445	502	73	26	14	42
Pseudo R^2	0.25	.016	0.10	0.12	0.33	0.27	0.26	0.07	0.11	0.15

Data source: DZHW School Leavers Survey 1990 (fourth wave)

Significance: +$p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Note: Chi^2 tests for differences between the coefficients of men and women have been performed : coefficients in italics differ between men and women at $p < 0.10$; coefficients in italics and bold differ between men and women at $p < 0.05$

throughout the academic career. This hypothesis was not entirely confirmed. Male engineering students are more likely to start doctoral studies than male economics students. Female engineering students do not show a similar advantage. The coefficients seem to suggest that women are less likely than men to start a doctoral programme in engineering (0.08 vs. 0.12), but the difference is not significant. In contrast, men with a doctorate in female-dominated fields, such as the humanities, relatively often access a post-doc position (0.18 vs. 0.09). Remarkably, men seem to benefit from a female-dominated context, while women apparently face gender-specific difficulties in a male-dominated context, which could be due to discrimination or negative expectations of the social environment (Kanter 1977; Spencer et al. 2016). Gender differences in the academic career not only emerge from gender-specific field of study choices, but also from different context effects for men and women within the same field of study.

In addition to differences confirming our theoretical expectations, we find further unexpected gender-specific effects of motivations, performances and context conditions. Firstly, motivations influence the educational career of men and women in different ways. While in transition to higher education women are more affected by cost considerations (− 0.06 vs. − 0.03), men are more affected by extrinsic motivation at the transition to a doctorate (0.01 vs. 0.00). In other words, the reasons that men and women decide to start or not to start an academic career differ between the sexes. Secondly, at the start of the academic career, performance is equally important for men and women. However, the effect of grades is stronger for men than for women in transition to a doctoral programme (0.14 vs. 0.08) and to a post-doc position (0.12 vs. 0.06). Men with above average grades have an especially increased probability to attain a post-doc position. With the data at hand we cannot check the reasons underlying this phenomenon. It may be that men are more oriented on grades in planning their academic career, or possibly the selection process for women in doctoral programmes or post-doc positions is less dependent on grades. Thirdly, we also find differing effects with regard to age and region (control variables). In particular, older men enrol less often in higher education (− 0.02 vs. 0.03) and less often start a doctorate programme (− 0.03 vs. 0.01); in contrast, the effect of age for women is positive. These unexpected findings show a need for further research in higher education with regard to gender-specific mechanisms on the path to an academic career.

Conclusions and outlook

The questions addressed in our study were: (1) At which steps in their academic career do women drop out? and (2) Which factors explain the pattern of gender inequality found? To answer these questions, we examined the academic careers of men and women from the very beginning of their academic career after completion of upper-secondary education to the first post-doc position. We applied a life course perspective in order to integrate arguments of individual decision-making with educational, familial, and work context conditions, which led to several hypotheses on why men and women could differ in academic careers. A first result is that gender differences become most apparent at transitions to the next educational stage rather than being caused by different graduation rates. Secondly, gender differences are more pronounced in the early stages of the academic career and less relevant at later stages. Thirdly, our

analyses identified several key factors explaining the career patterns of women and men: previous performance and intrinsic motivation fuel the initial stage and further pursuit of an academic career, while cost sensitivity and commitments to work or family are detrimental factors (similar results have been found in other countries by Castello et al. 2017; Contini et al. 2017; Klevan et al. 2016; Webber and Gonzalez Canché 2018). Fourthly, gender differences are partially explained by performance, but only to a very minor extent. The relatively low impact of performance seems surprising for an education system which is supposed to be governed by the principle of meritocracy and equal opportunities. Path dependencies of educational biographies, family and employment contexts further contribute to explaining the drop-out rate of women. However, a considerable proportion of variance is left unexplained. When we disregard any possible weaknesses of the data and analyses, the results of our analyses lead us to conclude that gender as an ascriptive factor has a strong impact on academic careers. Fifthly, separate analyses for women and men reveal that many mechanisms differ markedly by gender. Parenthood appears to impede academic career progression for both sexes, even though some studies indicate that women's careers are more affected than those of men (cf. Crabb and Ekberg 2014; Castello et al. 2017). However, while men with children more often decide not to *access* the next academic stage, women with family commitments less often *complete* academic stages. More generally, men and women differ in the impact of educational or work circumstances as well as in their reasons to start or stop an academic career in terms of motivation and performance. Several of these differences seem to be related to traditional gender roles that apparently have an effect even in modern societies. From an institutional perspective, the lower participation of women in doctoral studies and in acquiring post-doc positions could also be the result of discrimination processes; however, with our data we were not able to test such processes directly. Moreover, our results show that gender differences in academic careers cannot be solved by considering only the choice of a field of study as men and women within the same field of study differ in terms of their likelihood to pursue an academic career. The context of a male-dominated field seems to deter women from an academic career, but the same does not hold for men in female-dominated fields.

With the data at hand, gender differences in academic careers could not be fully explained. To some extent, this is certainly due to limited operationalisation of the theoretical concepts and missing variables. For example, our data set did not allow us to satisfactorily measure subjective expectations of men and women. Furthermore, the extent to which having children conflicts with pursuing an academic career depends on others being available to take care for children (Rusconi 2013) and institutional aspects on the demand side, such as the availability of female mentoring programmes or dual career services. However, these aspects could not be considered with the data available. Finally, Fritsch (2016) and Klevan et al. (2016) identified social capital and social networks to partially explain gender differences in access to and success in academic careers, but our data contained no measures of these constructs.

This study also provides opportunities for future research. It would be valuable to further investigate why women face disadvantages in male-dominated study fields, whereas men sometimes even benefit from studying and working in female-dominated fields. Theoretically, men's advantages in female-dominated fields could be explained to some extent by being a 'token' (Kanter 1977) with a higher status than the majority, but

it seems questionable that male students in the humanities are in fact considered to have a higher status than their female peers. In addition, the differing impact of grades and motivations on the academic career of women and men points towards the necessity for future research on the mechanisms underlying this phenomenon. Furthermore, the observed cohort (1990) is at the very beginning of the era of declining gender inequalities in access to higher education; therefore, it would be interesting to investigate the development of gender differences in times of educational expansion. The proportion of women among the students attaining a doctoral degree in Germany has risen from below one-third in the mid-1990s to 45% in 2016 (Federal Statistical Office 2017). However, taking into account the overrepresentation of women in upper-secondary education, actual studies show that selection processes change over time and move from earlier to later educational stages of the academic career (Lörz et al. 2011). The increasing participation of women in secondary education and higher education in the past decades could shift gender inequalities to later stages of the academic career. The German welfare state and educational system are prone to preserving existing gender differences, but it is a conservative system that is undergoing transition, and some of the policy changes in the last 15 years may have contributed to the growing participation of women in academic careers. These questions could be tackled with up-to-date life course data and contrasted with the findings of our study. In addition to the historical change of gender inequality, the comparison of gender differences across different educational systems and welfare states is another topic in need of further research. More generally, future research could replicate this study with more recent and better data.

Finally, the results of this study suggest policy changes to plug the leaks in the 'pipeline'. Firstly, actions aimed at increasing female participation in academic careers targeting transitions to higher education and doctoral programmes seem particularly advisable. Women have been shown to be especially sensitive to the costs of studying. Against this backdrop, more information on the returns of higher education and the excellent employment prospects of graduates in Germany could help. In contrast, ongoing discussions on the reintroduction of study fees in Germany seem to be counterproductive. Secondly, women in male-dominated fields are less likely to use the opportunity to begin on a doctoral programme. Efforts to appoint more female professors in these fields should be continued. Other measures, such as a quota for women on companies' advisory boards, introduced in 2016, may provide female role models and thus indirectly help in attracting more women for an academic career. Policy-makers and institutions could think of additional ways to support promising female students in male-dominated subjects, like mentoring programmes. However, the attention of policy-makers and researchers needs to shift to also balancing gender proportions in female-dominated fields of study. How can we attract more men to typical female-dominated subjects? Thirdly, the birth of a child notably hinders women from completing higher education or a doctorate, calling for a better compatibility of family and higher education. Expanding flexible child-care provisions and financial support for students with children would be helpful and could also alleviate fears to start an academic career. Equally desirable, child-care and financial safety would disburden male students with children and support their transition to doctoral programmes. Finally, overcoming gender inequalities in academic careers can be expected to have spill-over effects on reducing overall gender inequalities in the labour market. Female professors can serve as role models for students' careers within and outside academia.

Appendix

Table 5 Student population and sample information

Student population and sample information	Absolute numbers			Relative numbers		
	Male	Female	Total	Male	Female	Total
Student population[a]						
Upper secondary degree	147,552	127,198	274,750	0.54	0.46	1.00
Response sample[b]						
Fist wave	12,630	11,360	23,990	0.53	0.47	1.00
Second wave	8431	7446	15,877	0.53	0.47	1.00
Third wave	6169	5430	11,599	0.53	0.47	1.00
Fourth wave	3704	3408	7112	0.52	0.48	1.00
Analytical sample[b]						
Unweighted	3404	3242	6646	0.51	0.49	1.00
Weighted	3498	3148	6646	0.53	0.47	1.00

[a] Federal Statistical Office 2003

[b] DZHW School Leavers Survey 1990 (first to fourth wave)

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