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Gender Inequity during the Ph.D.: Females in the Life Sciences Benefit Less from Their Integration into the Scientific Community

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Abstract: Female researchers remain underrepresented in higher academic ranks, even within female-dominated fields, such as the life sciences. The phenomenon is often attributed to women's lower publication productivity. The current article explores gender differences with respect to integration into the scientific community, pursued tasks during the Ph.D. (e.g., teaching and research), and publication productivity in the life sciences. Moreover, it explores how these variables relate to the intention of pursuing an academic research career. Survey data with recent Ph.D. graduates from the life sciences in Germany (N = 736) were analyzed through descriptive and multivariate analysis. Females had fewer publications as lead author (1.4 vs. 1.9, $p = 0.05$). There were no differences in pursued tasks, perceived integration into the scientific community, and co-authorship. However, Ph.D. characteristics affected females and males differently. Only male Ph.D. graduates benefited from being integrated into their scientific community by an increase in lead author publications. In contrast to male Ph.D. graduates, women's academic career intentions were significantly affected by their integration into the scientific community and co-authorship. Results suggest that women may benefit less from their integration into the scientific community and may ascribe more importance to networks for their career progress.

Keywords: publication productivity; academic career; gender gap; Ph.D. education; life sciences; scientific community integration

1. Introduction

Despite an increase in the female study population at universities, females remain underrepresented in academic research worldwide (Sugimoto et al. 2013). The decreasing proportion of female scientists with higher ranks in academia is also referred to as "leaky pipeline" (e.g., Schubert and Engelage 2011). Moreover, it seems counterintuitive that especially in female-dominated academic fields, such as the life sciences, there is a high dropout of female postdocs when compared to male-dominated fields, such as those which are math-intensive (Lind and Löther 2007; Schubert and Engelage 2011; Ceci et al. 2014. In many countries, at least 50 percent of life sciences (Ph.D.) graduates are female (Feldon et al. 2017; Neugebauer 2006; Sheltzer and Smith 2014). However, only very few females in life sciences reach professorship. For example, in Germany, only around 10 percent of full professorships in the life sciences are held by women (Neugebauer 2006), while across all fields, they account for 20 percent of full professorships (Brodesser and Samjeske 2015). The patterns described above are very similar in Europe and the US, and therefore, are an object of concern internationally (Feldon et al. 2017; Neugebauer 2006;

Sheltzer and Smith 2014). Identifying barriers specific to female researchers is not only relevant to foster gender equality in academic research. It is also crucial to secure the next generations of talented academic researchers, especially in female-dominated fields. While many explanatory approaches to the female researcher dropout rate have been suggested, many questions also remain open. Especially in the field of life sciences, very little research has been conducted to analyze the barriers for female researchers throughout the different stages of their academic careers. This current research study explores some early career outcomes (publications and intentions to pursue an academic research career) of Ph.D. graduates in the life sciences, by gender, focusing on the (possible) role of integration into the scientific community, and activities during the Ph.D.

2. Literature and Research Questions

Explanatory approaches for the gender gap in academic research are diverse and range from individual characteristics (such as self-efficacy), to structural factors (such as family, networks, discrimination etc.). A highly cited reason for female researchers' lower career success is their averagely lower research productivity (Fox 2005; Jagsi et al. 2006; Sidhu et al. 2009; Sugimoto et al. 2013; Symonds et al. 2006). Indeed, publishing is one of the most important factors for employment in academic research, acquiring prestigious positions and attaining full professorship (Lutter and Schröder 2014; Plümper and Schimmelfennig 2007). Building a publication record in early career stages is, hence, an important step for the preparation of a successful academic research career (Feldon et al. 2017). However, it is questionable whether fewer publications merely are a cause, or also an effect of lower status and/or disadvantageous job characteristics of female academics. As Fox (2005) puts it: "Publication productivity reflects women's depressed rank and status, and partially accounts for it" (p. 31). Female postdocs in Germany are, for instance, four times more likely to work on a temporary contract and their contracts are shorter in comparison to those of their male counterparts (Konsortium Bundesbericht Wissenschaftlicher Nachwuchs 2013). Under such circumstances, publishing is probably more difficult. In addition, empirical results hint that women engage more in teaching than men do (Link et al. 2008; Winslow 2010). More time invested in teaching equals less time that can be invested in research, resulting in a penalty in publication productivity (Fox 1992).

Thus, rather than explaining women's underrepresentation with lower productivity, it should be a prior goal to explain publication differences by gender. While some studies do not support lower publication productivity by females (Schubert and Engelage 2011), this can be due to the fields of study analyzed, but also to local/geographical differences (Sugimoto et al. 2013). A recent study by Sugimoto et al. (2013), analyzing publication patterns worldwide and in various disciplines, supports that "[m]en dominate scientific production in nearly every country" (Sugimoto et al. 2013, p. 212). This applied to co- and first-authorships.

In addition to geographical differences and the differences among disciplines, career stages also need to be considered: While Ph.D. students, as surveyed by Schubert and Engelage (2011), may not vary so greatly with respect to their work and family circumstances, these might, however, become visible in the postdoc phase. It has been shown, for instance, that females' publication productivity is diminished one year after childbirth more so than for men (Hunter and Leahey 2010). Since academic researchers, fearing a negative impact on their career progression, start their family in later career stages (Metz-Göckel et al. 2014), Ph.D. students are less likely to have their first child in comparison to postdocs. Hence, childcare responsibilities will probably contribute to gender differences in a more advanced career stage. Different career stages are also likely associated to the variety of pursued activities. Ph.D. students may vary less with respect to the time invested in different academic activities, as their employment circumstances are more standardized. In the US, they usually pursue their Ph.D. within a graduate school and are not part of the academic staff. In Germany, the Ph.D. is most commonly achieved while having the position of a research assistant, on a scholarship, or within a graduate school (Kreckel 2011). While most Ph.D. students are conducting their thesis work as academic staff members, graduate schools with scholarship funding are becoming more popular (Konsortium Bundesbericht Wissenschaftlicher Nachwuchs 2017). In the life sciences, the Ph.D. is also recommended for students who want to pursue any career outside of academic research and is, therefore, almost considered the standard degree (Brockmann and Kühl 2015)–unlike in other disciplines, e.g., the social sciences (Destatis 2016). Since Ph.D. students were, until recently, not assessed by their universities, there is a lack of knowledge across all disciplines with respect to variables such as proportion of cumulative versus monographic theses, international collaboration, etc. (Konsortium Bundesbericht Wissenschaftlicher Nachwuchs 2017). With the recent introduction of a new law, however, universities are now obliged to gather information about their Ph.D. students and this knowledge gap will be closed in the future (Konsortium Bundesbericht Wissenschaftlicher Nachwuchs 2017). During the Ph.D. period it is plausible to assume that most Ph.D. students invests most of their time in conducting the research related to their Ph.D. project.

With respect to the life sciences, a recent study by Feldon and colleagues (2017) analyzed first year Ph.D. students. The study finds that female researchers, in contrast to their male counterparts, spent more time on supervised research in the laboratory, but were "rewarded" with fewer publications (mostly as a co-author). Research self-efficacy beliefs did not explain these differences. Indeed, a recent German study did not find gender differences in research self-efficacy beliefs in life sciences Ph.D. graduates (Epstein and Fischer 2017). Since in the study of Feldon and colleagues first year Ph.D. students mainly published as co-authors, it is possible that supervisors rewarded male and female Ph.D. students differently, and thus objective and transparent standards may be missing. This finding could hint at the so-called Matilda Effect (Rossiter 1993), describing a "systematic underrecognition of female scientists" (Knobloch-Westerwick et al. 2013). The Matilda Effect was recently tested and supported within an experimental research setting: study participants rated contributions of researches less favorably when they were labelled as coming from a female rather than a male researcher (Knobloch-Westerwick et al. 2013). This is in line with research showing gender stereotypes being linked to the evaluation of male and female behavior at the workplace. Expectations based on gender stereotypes, e.g., men are competent and women are caring, "can compromise a woman's career progress" (Heilman 2012, p. 114), since expectations also influence the perception of performance (Heilman 2012). Moreover, it has been found that successful females in male-dominated areas (such as academia) are liked less than equally successful males (Heilman et al. 2004). Being disliked can have detrimental effects on females' career progression and is related to salary and job opportunities (Heilman et al. 2004).

Considering the importance of networks for successful collaboration, the integration into the scientific community might be an important factor contributing to productivity differences. There is a "broad consensus that embeddedness in academic social networks—notably informal networks is both crucial for doing research, and for achieving a career" (Kegen 2013, p. 80). Collaborating with other researchers has also been related to publication outcome (Landry et al. 1996; Lee and Bozeman 2005). Moreover, collaborations are necessary for co-authorships, which can help to build up a publication record within a shorter time, than if only focusing on lead authorship (Feldon et al. 2017). Empirical evidence suggests that females are less integrated into their scientific communities (Kyvik and Teigen 1996; Schubert and Engelage 2011), or that their network ties are less beneficial (Feeney and Bernal 2010; Fuchs et al. 2001). A study of Fuchs et al. (2001) did not support gender differences with respect to scientific community integration; however, the authors found that contact to the scientific community only increased males' but not females' likelihood to stay employed in academic research (Fuchs et al. 2001). Accordingly, Schubert and Engelage (2011) found that male Ph.D. graduates acquired their first job more frequently thanks to social ties than women. These gender dependent outcomes of social ties are probably a matter of quality: quality of the tie (e.g., weak or strong) and/or characteristics of the contact/the social network and the social capital it entails. Furthermore, other research studies suggest that females tend to have a more local/domestic, and less international network in comparison to men (Abramo et al. 2013; Sugimoto et al. 2013). Homophily could also play a crucial role in recreating the disadvantageous position of women in the academic setting (Bozeman and Corley 2004; Kegen 2013). Bozeman and Corley find that 84 percent of collaborators of females in non-tenure track positions are also females. Since female researchers, on average, have lower academic ranks, it is likely that homophily is one reason female researchers seem to benefit less from their networks.

Concerning the occasionally conflicting results about the collaboration tendencies of each gender, the field of study is also an important factor. For instance, empirical studies suggest smaller gender differences in the social sciences (Hunter and Leahey 2008; Sugimoto et al. 2013). However, while Hunter and Leahey (2008) did not find gender differences in the collaboration frequency in a sample of researchers in sociology, they did not include the quality and benefit from collaborations of each gender in their study. As stated above, the career status may be of further importance when analyzing gender differences in integration/collaboration and interpreting empirical results. Investigating researchers who are well established in their field will probably reveal different results, since the population is already highly selected. Moreover, the problem of a selective sample at least partly applies to the mere analysis of publications, since it excludes researchers who miss publishing opportunities, e.g., due to a lack of collaborations.

Furthermore, integration into the scientific community could affect female and male researchers differently in their career decisions. Research has suggested that males are more driven by their achievements, whereas females seem to be more influenced by social cues (Hoffman 1972; Widom and Burke 1978; Mottaz 1986; Kim 2005). While in the German context, female life sciences Ph.D. graduates seem to aspire for an academic research career as much as their male counterparts, at least at that early career stage (Epstein and Fischer 2017), it is possible that different variables influence their intentions. Male Ph.D. graduates may be more driven by their objective achievements (publications) and females may bestow a greater importance to cues of social embeddedness. In this context, the article explores three research questions:

Research Question 1: Do male and female Ph.D. students differ with respect to their pursued tasks during the Ph.D. and their publication outcomes?

Research Question 2: Are Ph.D. characteristics (pursued tasks and integration into the scientific community) associated differently with publication outcomes, depending on gender?

Research Question 3: Do Ph.D. characteristics and outcomes affect the intention to pursue an academic research career differently, depending on gender?

3. Methods

3.1. Sample

Data of the E-Prom online survey of Ph.D. graduates in Germany was used[1]. Ph.D. graduates of 13 German universities who graduated from biological faculties were analyzed. The participants received their Ph.D. at maximum one year prior to the study and were asked retrospectively about their Ph.D. period. The survey was conducted in 2013, 2014 and 2015. To achieve a higher sample size,

[1] The E-Prom survey is an ongoing project analyzing doctoral education and careers in the basic life sciences and medicine. It is one attempt to gather more information about the Ph.D. phase in Germany. Since universities were until recently not obliged to assess their Ph.D. students, information on this qualification period is missing. The study is conducted by the Klinikum der Universität München, the Ludwig-Maximilians-Universität München, the Universität zu Köln and the Technische Universität München. All universities in Bavaria, Saxony and North-Rhine Westphalia with a medical and life sciences department were invited to participate. The participation of the universities was voluntary and the data are not representative. Data of the study are available at the data repository of GESIS (study numbers ZA6762 and ZA6763). More information can also be found here: www.e-prom-project.de.

the datasets of these years were combined. Due to the short time intervals between the surveys and no major educational reforms or changes in the academic or non-academic labor market, combining the datasets is not problematic with respect to the concerned variables, e.g., intention to pursue an academic research career. Doctoral graduates older than 40 years (N = 34) were excluded from the analysis, due to the limited possibilities to pursue an academic research career when completing the doctorate at that age in Germany.[2] The final sample comprised 730 life sciences Ph.D. graduates, with most females (60 percent) as expected. Female and male graduates did not significantly differ in age (with a females' mean age of 31.15 (SD = 2.37) years and males being 31.8 (SD = 2.25) years old on average.

3.2. Measures

To validate the scales that were used within the analysis, we used Categorical Principal Component Analysis (CatPCA) and Confirmatory Factor Analysis (CFA) (Brown and Moore 2012; Casacci and Pareto 2015). CatPCA is typically applied when the manifest indicators are assumed to be the cause of the latent variable, here this was the case for the scales of integration into the work group and scientific community (see Appendix A, Table A1). CFA is typically applied when the indicators are assumed to be the result of the latent variable, e.g., attitudinal sales, here those scales were academic career intention and intrinsic research motivation (see Appendix A, Tables A2 and A4).[3]

Publications. The number of first and co-author research papers, that were published or accepted for publication during the Ph.D. period were assessed. We distinguished between publications as first and co-author since first author publications are most relevant to career progress in academic research (Lutter and Schröder 2014). However, publishing as a co-author is also an indicator for being integrated into the scientific community and successful collaboration with other researchers.

Pursued Tasks. Participants were asked what percentage of their working hours they spent on various tasks. Time spent on (1) the Ph.D. project; (2) research not related to the Ph.D. project; (3) administrative tasks; and (4) teaching were relevant for the current research question. While the relative time spent on tasks does not necessarily reflect the total time spent on a task, there were no significant gender differences with respect to the total working hours per week (47.47 h for females and 48.36 h for males).

Integration into the Scientific Community. Integration into the scientific community was measured with two scales, assessing the subjective integration into the local working group and one's scientific community in general. The integration into the local working group was assessed by an eight item 5-point Likert scale (1 = completely disagree; 5 = completely agree). The items included ratings about how well the respondent knew members of his/her working group and scientific community, and about being able to address members for any questions that they might have had, etc. Applying CatPCA, both scales revealed a two dimensional-solution: (1) Integration into the work group/scientific community and (2) cooperative atmosphere in the work group/scientific community. The two dimensions for each scale were saved as latent variables with a mean of 0 and a standard deviation

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2 Chances for acquiring a long-term position in academia are particularly low in Germany and almost exclusively possible with a position as a full professor, which account for about 10 percent of all positions in German academia (Fitzenberger and Schulze 2014; Kreckel 2010). Full professors are usually appointed at around an age of 40 (Lind and Löther 2007).

3 Both Factor Analysis (FA) and CatPCA (and also principal component analysis) are methods applied to reduce dimensions. Differences are that FA considers variations in the observed variables as a result of variations in unobserved, latent variables (i.e., factors) (reflective approach), while CatPCA is a formative method that considers principal components/factors as the sum of their observed variables (Bollen 2011; Bollen and Diamantopoulos 2017). Moreover, in CatPCA, principal components are modeled as non-linear combinations of their observed variables, in FA manifest variables are modeled as linear outcomes of their assumed underlying latent factors (Brown et al. 2011). In the case of integration and cooperation/competition in the work group/ scientific community, it is more reasonable to assume that these items represent manifest characteristics of actual integration and competition/cooperation which 'sum up' to the latent variables. We applied CatPCA to the scales of integration into the work group and scientific community (see Appendix A, Table A1) and CFA to the scales of academic career intention and intrinsic research motivation (see Appendix A, Tables A2 and A4).

of 1 (cf. Appendix A, Table A1). In order not to lose the respondents who indicated that they had no contact with a working group at all, we included a dummy variable (0 = no contact to a work group; 1 = contact to a work group) in the multivariate analysis. Using full information maximum likelihood (FIML) these cases remain in our analyses.

Academic Career Intention. Based on Berweger and Keller (2005), the intention to pursue an academic research career in the long-term was assessed with three 5-point Likert scaled items, asking whether in the long run respondents aspire for (1) an academic research career; (2) professorship; or (3) a career outside the field of academic research. CFA indicated a one-dimensional scale (cf. Appendix A, Table A2), showing weak measurement invariance between men and women (cf. Appendix A, Table A3). Hence, differences in mean values must be evaluated with caution.

Control Variables. Further control variables were added. These were: the indicated intrinsic research interest as a reason to start the doctorate, whether one was working on a monograph thesis or a cumulative/publication-based thesis (dummy variable), and the number of international research stays. Working on a monograph, rather than a cumulative dissertation composed of articles, can inhibit publication productivity. The number of international research stays was added as a control variable, since important contacts to the scientific community can be established during such periods.

Getting a Ph.D. in the life sciences is very common in Germany, and even recommended for better career chances outside of academic research (Falk and Reimer 2007; Hornbostel 2012), therefore, intrinsic research interest can have a significant influence on the structure and the outcomes of the Ph.D., such as publications. Intrinsic research interest was assessed by four 5-point Likert scaled items. Respondents were asked to what extent they started their Ph.D. to (1) to deepen their professional knowledge; (2) to do research during their Ph.D. and (3) to work intensely on the topic of their Ph.D. The CFA suggested a single latent variable for the items (cf. Appendix A, Table A4) and strong measurement invariance between men and women (cf. Appendix A, Table A5).

The dataset includes one variable that assesses the number of children. Since most participants had no children yet (87 percent) and important information, i.e., children's age (Hunter and Leahey 2010), was missing, the variable was not included in the analysis.

3.3. Data Analysis

Analyses were carried out with the statistical package MPlus, version 7.3 (Muthén and Muthén 2004). To explore gender differences in the variables of interest, bivariate analyses were conducted with the statistical package Stata, release 12 (Stata Corp 2011). Multivariate Poisson-regressions with robust FIML were conducted to analyze the number of publications as the dependent variable. We present the unstandardized regression coefficients and the IRR (incident rate ratio), which is interpreted as follows: the expected number of observations of the dependent variable is multiplied by the IRR, when the independent variable increases by one unit. A multivariate linear regression analysis with robust FIML was conducted to explore the relationship between Ph.D. characteristics and Ph.D. outcomes on the intention to pursue an academic research career.

4. Results

4.1. Bivariate Results

Bivariate results differentiating between female and male respondents, for all dependent, independent, and control variables are shown in Table 1. Females published significantly less first author articles within the Ph.D. period than their male counterparts. There were no significant differences in the number of articles as co-author. In accordance with previous analyses (Epstein and Fischer 2017), there were no significant differences regarding the intention to pursue an academic research career in the long-term. As argued in the introduction, respondents invested most of their time into research related to their Ph.D. project (around 70 percent) and close to twenty percent of their time into research unrelated to the Ph.D. Moreover, they spent 10 percent of their time each on teaching and administrative tasks. Apart from males investing a little more time on administrative tasks (8 vs. 12 percent), there were no gender differences.

Regarding their work-related social embeddedness, Ph.D. graduates rated their working group integration positively overall. The integration into the scientific community as a whole was, not surprisingly, rated somewhat lower.

Concerning the control variables, most male and female graduates (around 70 percent), composed a monograph thesis, indicating that a publication-based thesis has, overall, not established itself yet in the German life sciences. Intrinsic research interest was, for females as well as for males, an important motivation to start a Ph.D. International research stays were rather uncommon among the survey respondents, with females reporting significantly fewer stays.

Table 1. Gender Differences in Dependent, Independent and Control Variables.

	Females			Males			
	M	**SD**	**N**	**M**	**SD**	**N**	**Cohen's d**
Dependent Variables							
Publications as First Author	1.4	1.4	380	1.9	2.3	243	−0.31 **
Publications as Co-Author	2.0	2.1	372	2.3	2.3	239	−0.11
Academic Career Intensions	2.2	1.2	367	2.4	1.1	233	−0.15
Independent Variables							
Time on Ph.D. Project (in Percent)	74.2	19.2	330	73.2	19.1	200	0.05
Time on Research Other than Ph.D. (in Percent)	17.1	21.1	310	19.6	22.8	184	−0.12
Time on Teaching (in Percent)	9.9	15.0	298	12.7	17.0	180	−0.18
Time on Administrative Tasks (in Percent)	8.3	10.6	296	10.6	12.4	184	−0.21 *
Integration into the Scientific Community							
Working Group Integration	4.4	0.7	356	4.3	0.7	225	0.09
Cooperative Working Group Atmosphere	4.1	0.8	350	4.1	0.7	228	−0.07
Scientific Community Integration	2.9	0.9	286	3.0	0.9	183	−0.08
Cooperative Atmosphere in Scientific Community	3.1	0.8	262	3.1	0.9	184	0.05
Control Variables							
International Research Stays	0.5	1.3	391	0.7	1.7	254	−0.19 *
Intrinsic Research Interest	4.0	0.8	399	4.0	0.8	254	−0.05
Monograph Thesis (in Percent)	76.5		417	75.4		260	1.10

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

There were no significant gender differences in the analyzed variables that could explain the gender difference in first author articles, except for research stays abroad. However, the male advantage remained significant (ß = 0.14, SE = 0.04, $p = 0.000$) when controlling for international research stays, which were significantly related to first author publications (ß = 0.13, SE = 0.04, $p = 0.003$).

4.2. Multivariate Results

Publications. To assess whether any of the independent variables were differently associated with publication outcomes for females and males, multi-group Poisson-regression analyses, with first and co-author publications as dependent variables, were conducted. The results are depicted in Tables 2 and 3.

Table 2. Factors Associated with First Author Publications for Females and Males.

	Females			Males		
	b	**IRR**	**SE**	**b**	**IRR**	**SE**
Time on Ph.D. project	−0.01 **	0.99	0.00	−0.01	0.99	0.00
Time on Research Other than Ph.D.	0.00	1.00	0.00	0.00	1.00	0.00
Time on Administrative Tasks	0.00	1.00	0.00	0.00	1.00	0.01
Time on Teaching	0.00	1.00	0.00	0.00	1.00	0.01
Working Group Integration	0.00	1.00	0.06	0.05	1.05	0.07
Cooperative Working Group Atmosphere	−0.01	0.99	0.05	−0.01	0.99	0.08
Scientific Community Integration	0.09	1.09	0.05	0.24 **	1.27	0.08
Cooperative Atmosphere in Scientific Community	−0.07 **	0.93	0.03	−0.07	0.93	0.08
International Research Stays	0.00	1.00	0.03	0.02	1.02	0.03
Monograph Thesis	−0.67 ***	0.51	0.08	−0.58 **	0.56	0.14
Intrinsic Research Interest	0.01	1.01	0.09	0.21	1.24	0.17
Constant	2.08 ***		0.23	2.05 ***		0.33
N	429			270		
Loglikelihood	−17,360					
AIC	34,992					
SBIC	35,179					

Note: Zero-inflated Poisson-regression. Unstandardized coefficients (**b**) and standard errors (SE), rounded to the first; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 3. Factors Associated with Co-Authored Publications for Females and Males.

	Females			Males		
	b	**IRR**	**SE**	**b**	**IRR**	**SE**
Time on Ph.D. project	−0.01	0.99	0.02	−0.01	0.99	0.01
Time on Research Other than Ph.D.	0.01	1.01	0.00	0.00	1.00	0.01
Time on Administrative Tasks	0.01	1.01	0.01	0.00	1.00	0.01
Time on Teaching	0.00	1.00	0.03	−0.01	0.99	0.01
Working Group Integration	0.15	1.16	0.47	0.08	1.08	0.09
Cooperative Working Group Atmosphere	−0.01	0.99	0.06	−0.08	0.92	0.10
Scientific Community Integration	0.07	1.07	0.06	0.15	1.16	0.11
Cooperative Atmosphere in Scientific Community	−0.04	0.96	0.18	0.09	1.10	0.11
International Research Stays	−0.06 *	0.94	0.21	0.05	1.05	0.04
Monograph Thesis	−0.41 *	0.67	0.21	−0.03	0.97	0.17
Intrinsic Research Interest	−0.10	0.90	0.20	0.38	1.47	0.20
Constant	2.40 **		0.81	1.49		0.79
N	429			270		
Loglikelihood	−17,531					
AIC	35,334					
SBIC	35,521					

Note: Zero-inflated Poisson-regression. Unstandardized coefficients (**b**) and standard errors (SE), rounded to the first. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

For both males and females, working on a monograph thesis was negatively associated with first author publications (Table 2). Moreover, only for males was scientific community integration positively associated with first author publications. Interestingly, a cooperative atmosphere in the scientific community was negatively related to females' first author publications; however, the meaningfulness of this association is questionable due to the small effect size. For females, the time spent on the Ph.D. thesis was negatively related to first author publication outcome. This effect size was, however, negligibly small. The same applies to the negative association between working on a monographic thesis, international research stays and co-author publications in females (Table 3).

For the male respondents, none of the variables analyzed were associated with co-author publications.

Academic Career Intentions. Whether publication outcome and other characteristics of the Ph.D. had different effects on females and males' intention to pursue an academic research career was a further object of analysis. The results of the multivariate regression analyses are depicted in Table 4. For both males and females, intrinsic research interest was positively related to the intention to pursue an academic research career. While first author publications and international research stays were positively associated for male Ph.D. graduates only, co-authored articles and a sense of being integrated into the scientific community were positively associated to females' academic career intentions. Further, the time spent on administrative tasks was positively associated with academic career intentions, for females. However, we dismiss this association, due to the very small effect size.

Table 4. Factors Associated with Academic Career Intentions for Females and Males.

	Females		Males	
	b	**SE**	**b**	**SE**
First Author Articles	0.07	0.06	0.15 *	0.06
Co-Author Articles	0.11 **	0.04	0.02	0.04
Time on Ph.D. Project	0.01	0.01	0.00	0.01
Time on Research Other than Ph.D.	0.00	0.00	0.00	0.01
Time on Administrative Tasks	0.01 *	0.01	0.01	0.01
Time on Teaching	0.00	0.01	0.00	0.01
Working Group Integration	−0.12	0.08	−0.12	0.10
Cooperative Working Group Atmosphere	−0.01	0.08	−0.02	0.11
Scientific Community Integration	0.19 **	0.07	0.14	0.11
Cooperative Atmosphere in Scientific Community	−0.02	0.06	−0.12	0.09
International Research Stays	0.11	0.07	0.10 *	0.05
Monograph Thesis	−0.14	0.18	−0.25	0.27
Intrinsic Research Interest	0.66 ***	0.13	0.59 **	0.17
Constant	−1.20	1.00	0.00	1.00
N	429		270	
Adj. R^2	0.23		0.20	

Note: Multivariate regression analysis. Unstandardized coefficients (b) and standard errors (SE), rounded to the first. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

5. Discussion

With respect to Research Question 1 (cf. Chapter 2) the results of our study showed no significant difference in the relative time spent on the tasks during the Ph.D. (research, teaching, and administrative tasks) between female and male Ph.D. students in the life sciences. However, in line with previous research results (Fox 2005; Sidhu et al. 2009; Sugimoto et al. 2013; Symonds et al. 2006), women published significantly less. This applied to first author articles, but not the number of articles as a co-author. Surprisingly, a cooperative atmosphere in the scientific community was linked to a lower number of first author publication for females. This result may indicate that females are more motivated to publish in competitive environments. However, since the effect size was rather small, this potential link is rather a topic for future research.

Since research articles in the life sciences usually have a large number of co-authors (Tscharntke et al. 2007), the position and number of co-authors is an important indicator of author's contribution (Abramo et al. 2013). These aspects were not assessed and limit our results as we only captured the number of co-authored articles but neither the relative position in the authors' list nor the number of co-authors. This may be one reason, why gender differences could only be found for first authorship but not for co-authors. The perceived integration into the scientific community and working group did not differ by gender. Since we did not measure social ties directly, respondents' perception could have deviated from their actual embeddedness.

Research Question 2 asked, whether Ph.D. characteristics are differently associated to Ph.D. outcomes by gender. In agreement with previous research, indicating that female Ph.D. students benefit less from supervised research by publication output (Feldon et al. 2017), the results of our analyses show that only for males integration into the scientific community is related to significantly more publications as a first author. This could mean various things: it may be possible that males are more successful in using their social capital i.e., asking contacts for advice, finding established researchers as co-authors, etc. As already mentioned in the introduction of this paper, males and females' networks differ with respect to the gender of their contacts and (inter)nationality. Their professional contacts could, moreover, differ substantially in rank and experience. As stated earlier, the indirect measure of social ties, i.e., missing information on the quantity and quality of males' and females' scientific contacts, could have biased the results of males and females' embeddedness. Females may just feel as embedded as males, but their contacts could be of lower rank, or less prestigious, and their ties may be weaker. Our results are limited with respect to these details since these measures were not included. With respect to success at using one's social capital it is important to note that in Germany, Ph.D. students are highly dependent on their supervisors (Berning and Falk 2005). Attempts involving the introduction of more structure and an increase in the number of supervisors to the Ph.D. have been made to resolve this situation. Hence, with respect to attaining first authorship on the project they work on during their Ph.D., students may yet be at the mercy of their supervisors. In addition, the common practice of "gift authorship"[4] in the life sciences (cf. Tscharntke et al. 2007) is an indicator that fair practices in attributing authorship may not always be present. Supervisors' behavior towards male and female Ph.D. students and practices of attributing authorship during and beyond the Ph.D. should be analyzed by future studies.

In consideration of evidence supporting the Matilda Effect (cf. Introduction), it is also possible that male Ph.D. students are more often offered lead authorship in cooperative projects. As described in the Introduction, a person's gender is linked to performance evaluations (Heilman 2012). Also a recent study (Sarsons 2017) provides evidence "that a person's gender influences the way others interpret information about his or her ability" (Sarsons 2017, p. 1). In her study, female surgeons were not only punished (drop in referrals) more after the death of a patient; they also benefited less from good patient outcomes compared to their male colleagues (lower increase in referrals). Further, results pointing to the different liking expressed towards successful females and males (Heilman et al. 2004) could be meaningful: If talented female researchers are disliked more than their male counterparts, superiors and colleagues may be less inclined to support their career progression. The reason(s) why males seem to profit more from their social embeddedness is an important topic to be investigated in the future.

Pertaining to the kind of compiled thesis, working on a monograph thesis in comparison to a cumulative thesis, was associated with fewer articles as a first author. The result is not surprising, since a cumulative thesis is linked to a certain number of mandatory publications. The result clearly suggests that a certain publication obligation to attain a Ph.D., is beneficial in the life sciences. Since paper publications in peer reviewed articles are most important for a future successful academic research career (Lutter and Schröder 2014; Plümper and Schimmelfennig 2007), this aspect should be considered for regulations in Ph.D. programs.

The third research question asked, whether female and male Ph.D. graduates are influenced differently in their career decisions through Ph.D. characteristics and outcomes. While intrinsic research motivation highly correlated with the intention to pursue an academic research career for both genders, first author publications were only significant within the male group. For females, co-authored articles and feeling integrated into the scientific community were significantly related

[4] Gift authorship is a "practice where co-authorship is awarded to a person who has not contributed significantly to the study" (Bülow and Helgesson 2018, p. 1).

to their academic career intentions. Since upper ranks in academic research are still male-dominated and working together with other scientists is especially crucial for being successful in the life sciences, it may be possible that females ascribe more importance to their network for career success than men.

The importance males and females ascribe to different aspects for their career progress should be analyzed in the future. Moreover, the kinds of collaborations male and female Ph.D. students have within and outside their working group should be analyzed, to better understand why the same level of self-rated integration and cooperation is related to a greater number of first author publications for male but not female Ph.D. students. Since first author publications are among the most important factors for furthering one's career in academic research and eventually being appointed as a full professor (Lutter and Schröder 2014), it is important to understand the pitfalls which lead to a lower first author publication outcome for females. Understanding the mechanism behind the gender difference of our study (effect of scientific community integration only positively associated to first author publications for male Ph.D. students), is crucial to derive practical implications. Supporting female Ph.D. students with their attempts to build a network in the scientific community and/or sensitizing supervisors with respect to that topic could be fruitful. Further, Ph.D. students can benefit from their scientific contacts on many other levels. A sense of integration itself may be related to a higher motivation to pursue an academic research career, elicit creative new research ideas and projects, etc.

Our results are not readily transferable to other fields with different gender ratios and disciplinary cultures. More research is needed to analyze whether these patterns can be found in other domains, such as, e.g., the social sciences or math-intensive fields. Furthermore, our results are limited with respect to missing variables in the dataset: childcare responsibilities could have had a different impact on males' and females' publication output. As noted, however, academic researchers often postpone their family planning to later career stages out of concerns regarding their career progression (Metz-Göckel et al. 2014). For Ph.D. students, this aspect may not yet have been relevant. In alignment with previous findings, the majority of our participants was still childless (cf. chp. 3.1.). As mentioned before, data regarding the number of co-authors and position as co-author were missing. Since this is a crucial aspect in the assessment of research productivity in the life sciences, (Abramo et al. 2013) our results on co-authorship may be biased. The number of co-authors and their relative position in authors' lists should be analyzed by future research.

6. Materials and Methods

The data and syntaxes used in this manuscript are available from the Figshare Repository with the doi:10.6084/m9.figshare.6383360.

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Appendix A

Table A1. Working Group and Scientific Community Integration. Factor Loadings of CatPCA.

Working Group: During My Doctoral Education …	Factor 1	Factor 2
I knew all members of the work group very well	0.98	−0.13
All members of the work group knew me very well	0.97	−0.10
I felt like an important member of the work group	0.66	0.27
I had the impression that I was taken seriously by my work group	0.42	0.53
I felt I could always ask the members of my work group for advice	0.07	0.78
the atmosphere in my work group was very cooperative	0.11	0.83
the atmosphere in my work group was very competitive	0.24	−0.68
Eigenvalue	3.42	1.39
N	608	
Scientific Community: During my Doctoral Education …		
I knew a lot of members of my scientific community personally	0.95	−0.14
a lot of members of my scientific community knew me personally	0.94	−0.08
I felt like a member of my scientific community	0.91	−0.02
I had the impression that I was taken seriously within my scientific community	0.76	0.20
I felt I could always ask the members of my scientific community for advice	0.66	0.35
the atmosphere in my scientific community was very cooperative	0.41	0.56
the atmosphere in my scientific community was very competitive	0.16	−0.95
Eigenvalue	4.11	1.22
N	608	

Note: Promax rotation, pattern matrix, numbers rounded to the second decimal place.

Table A2. Academic Career Intentions: Factor Loadings of CFA.

In the Long Run, I Want to Pursue …	Men	Women
an academic research career	0.98	0.96
a professorship	0.88	0.87
a career outside academic research	−0.57	−0.61

Note: standardized factor loadings; FIML estimation; N = 610, numbers rounded to the second decimal place.

Table A3. Measurement Invariance of Academic Career Intentions.

	RMSEA	CFI	SRMR	C1	C0	D1	D0	F1	F0	Satorra-Bentler Scaled Chi^2	df	*p*
configural model	0.00	1.00	0.00									
weak invariance	0.03	1.00	0.04	1.1	1.1	0	2	0	2.43	2.43	2	0.297
strong invariance	1.12	0.96	0.06	1.1	1.1	0	5	0	26.18	26.18	5	0.000

Note: C1 = scaling factor of free model (configural model); C0 = scaling factor of constrained model; D1 = degrees of freedom of free model (configural model); D0 = degrees of freedom of constrained model; F1 = Chi^2 value of free model (configural model); F0 = Chi^2 value of constrained model. A significant Satorra-Bentler Scaled Chi^2 indicates a significantly higher Chi^2 value of the constrained model. Estimation of Satorra-Bentler Scaled Chi^2: (F0 * C0−F1 * C1) * (D0−D1)/C0 * D0−C1 * D1).

Table A4. Intrinsic Research Motivation: Factor Loadings of CFA.

I Wanted to Pursue a Ph.D. …	Men	Women
to enlarge their professional knowledge	0.61	0.66
to do research during their Ph.D.	0.78	0.71
to work intensely on the topic of their Ph.D.	0.76	0.69
N	692	

Note: standardized factor loadings rounded to the second decimal place; FIML estimation, numbers rounded to the second decimal place.

Table A5. Measurement Invariance of Intrinsic Research Motivation.

	RMSEA	CFI	SRMR	C1	C0	D1	D0	F1	F0	Satorra-Bentler Scaled Chi^2	df	*p*
configural model	0.00	1.00	0.00									
weak invariance	0.00	1.00	0.05	1	1.24	0	2	0	1.89	1.89	2	0.389
strong invariance	0.00	1.00	0.04	1	1.10	0	5	0	4.53	4.53	5	0.476

Note: C1 = scaling factor of free model (configural model); C0 = scaling factor of constrained model; D1 = degrees of freedom of free model (configural model); D0 = degrees of freedom of constrained model; F1 = Chi^2 value of free model (configural model); F0 = Chi^2 value of constrained model. A significant Satorra-Bentler Scaled Chi^2 indicates a significantly higher Chi^2 value of the constrained model. Estimation of Satorra-Bentler Scaled Chi^2: (F0 * C0−F1 * C1) * (D0−D1)/C0 * D0−C1 * D1).

References

Abramo, Giovanni, Ciriaco Andrea D'Angelo, and Francesco Rosati. 2013. The importance of accounting for the number of co-authors and their order when assessing research performance at the individual level in the life sciences. *Journal of Informetrics* 7: 198–208. [CrossRef]

Berning, Ewald, and Susanne Falk. 2005. Das Promotionswesen im Umbruch. *Beiträge zur Hochschulforschung* 27: 48–72.

Berweger, Simone, and Carmen Keller. 2005. Prädiktoren der akademischen Laufbahnintention: Ergebnisse einer geschlechtervergleichenden Befragung von Doktorandinnen und Doktoranden auf dem Hintergrund der sozial-kognitiven Laufbahntheorie. *Zeitschrift für Pädagogische Psychologie* 19: 145–58. [CrossRef]

Bollen, Kenneth A. 2011. Evaluating Effect, Composite, and Causal Indicators in Structural Equation Models. *Mis Quarterly* 35: 359–72. [CrossRef]

Bollen, Kenneth A., and Adamantios Diamantopoulos. 2017. In Defense of Causal-Formative Indicators: A Minority Report. *Psychological Methods* 22: 581–96. [CrossRef] [PubMed]

Bozeman, Barry, and Elizabeth Corley. 2004. Scientists' Collaboration Strategies: Implications for Scientific and Technical Human Capital. *Research Policy* 33: 599–616. [CrossRef]

Brockmann, Dieter, and Michael Kühl. 2015. *Mit Erfolg Promovieren in Den Life Scienecs: Ein Leitfaden für Doktoranden, Betreuer und Universitäten (Vol. 1)*. Stuttgart: UTB.

Brodesser, David, and Kathrin Samjeske. 2015. *Professorinnenanteile-Entwicklung und Szenarien für Vergangenheit und Zukunft*. GESIS Papers, 2015/21. Köln: GESIS—Leibniz-Institut für Sozialwissenschaften.

Brown, Timothy A., and Michael T. Moore. 2012. Confirmatory Factor Analysis. In *Handbook of Structural Equation Modeling*. Edited by Hoyle Rick H. New York: Guildford Press, pp. 361–79.

Brown, Bruce L., Suzanne B. Hendrix, Dawson W. Hedges, and Timothy B. Smith. 2011. *Multivariate Analysis for the Biobehavioral and Social Sciences: A Graphical Approach*. New York: John Wiley & Sons.

Bülow, William, and Gert Helgesson. 2018. Hostage authorship and the problem of dirty hands. *Research Ethics* 14: 1–9. [CrossRef]

Casacci, Sara, and Adriano Pareto. 2015. Methods for Quantifying Ordinal Variables: A Comparative Study. *Quality & Quantity* 49: 1859–72.

Ceci, Stephen J., Donna K. Ginther, Shulamit Kahn, and Wendy M. Williams. 2014. Women in academic science: A changing landscape. *Psychological Science in the Public Interest* 15: 75–141. [CrossRef] [PubMed]

Stata Corp. 2011. *Stata Statistical Software: Release 12*. College Station: StataCorp LP.

Destatis. 2016. *Promovierende in Deutschland. Wintersemester 2014/2015*; Wiesbaden: Statistisches Bundesamt.

Epstein, Nurith, and Martin R. Fischer. 2017. Academic Career Intentions in the Life Sciences: Can Research Self-Efficacy Beliefs Explain Low Numbers of Aspiring Physician and Female Scientists? *PLoS ONE* 12: e0184543. [CrossRef] [PubMed]

Falk, Susanne, and Maike Reimer. 2007. Verschiedene Fächer, Verschiedene Übergänge: Der Berufseinstieg Und "Frühe" Berufserfolg Bayerischer Hochschulabsolventen. *Beiträge zur Hochschulforschung* 29: 34–70.

Feeney, Mary K., and Margarita Bernal. 2010. Women in Stem Networks: Who Seeks Advice and Support from Women Scientists? *Scientometrics* 85: 767–90. [CrossRef]

Feldon, David F., James Peugh, Michelle A. Maher, Josipa Roksa, and Colby Tofel-Grehl. 2017. Time-to-Credit Gender Inequities of First-Year Ph.D. Students in the Biological Sciences. *CBE-Life Sciences Education* 16: ar4. [CrossRef] [PubMed]

Fitzenberger, Bernd, and Ute Schulze. 2014. Up or Out: Research Incentives and Career Prospects of Postdocs in Germany. *German Economic Review* 15: 287–328. [CrossRef]

Fox, Mary F. 1992. Research, Teaching, and Publication Productivity: Mutuality Versus Competition in Academia. *Sociology of Education* 65: 293–305. [CrossRef]

Fox, Mary F. 2005. Gender, Family Characteristics, and Publication Productivity among Scientists. *Social Studies of Science* 35: 131–50. [CrossRef]

Fuchs, Stefan, Janina Von Stebut, and Jutta Allmendinger. 2001. Gender, Science, and Scientific Organizations in Germany. *Minerva* 39: 175–201. [CrossRef] [PubMed]

Heilman, Madeline E. 2012. Gender stereotypes and workplace bias. *Research in Organizational Behavior* 32: 113–35. [CrossRef]

Heilman, Madeline E., Aaron S. Wallen, Daniella Fuchs, and Melinda M. Tamkins. 2004. Penalties for success: Reactions to women who succeed at male gender-typed tasks. *Journal of Applied Psychology* 89: 416–27. [CrossRef] [PubMed]

Hoffman, Lois Wladis. 1972. Early Childhood Experiences and Women's Achievement Motives. *Journal of Social Issues* 28: 129–55. [CrossRef]

Hornbostel, Stefan. 2012. Einleitung. In *Der Doktortitel Zwischen Status Und Qualifikation*. Edited by Huber Nathalie, Anna Schelling and Stefan Hornbostel. Berlin: iFQ Institut für Forschungsinformation und Qualitätssicherung, pp. 7–9.

Hunter, Laura, and Erin Leahey. 2008. Collaborative Research in Sociology: Trends and Contributing Factors. *The American Sociologist* 39: 290–306. [CrossRef]

Hunter, Laura, and Erin Leahey. 2010. Parenting and Research Productivity: New Evidence and Methods. *Social Studies of Science* 40: 433–51. [CrossRef]

Jagsi, Reshma, Elizabeth A. Guancial, Cynthia Cooper Worobey, Lori E. Henault, Yuchiao Chang, Rebecca Starr, Nancy J. Tarbell, and Elaine M. Hylek. 2006. The "Gender Gap" in Authorship of Academic Medical Literature—A 35-Year Perspective. *New England Journal of Medicine* 355: 281–87. [CrossRef] [PubMed]

Kegen, Nadine V. 2013. Science Networks in Cutting-Edge Research Institutions: Gender Homophily and Embeddedness in Formal and Informal Networks. *Procedia-Social and Behavioral Sciences* 79: 62–81. [CrossRef]

Kim, Sangmook. 2005. Gender differences in the job satisfaction of public employees: A study of Seoul Metropolitan Government, Korea. *Sex Roles* 52: 667–81. [CrossRef]

Knobloch-Westerwick, Silvia, Carroll J. Glynn, and Michael Huge. 2013. The Matilda Effect in Science Communication: An Experiment on Gender Bias in Publication Quality Perceptions and Collaboration Interest. *Science Communication* 35: 603–25. [CrossRef]

Konsortium Bundesbericht Wissenschaftlicher Nachwuchs. 2013. *Bundesbericht Wissenschaftlicher Nachwuchs 2013. Statistische Daten Und Forschungsbefunde Zu Promovierenden Und Promovierten in Deutschland*; Bielefeld: wbv.

Konsortium Bundesbericht Wissenschaftlicher Nachwuchs. 2017. *Bundesbericht Wissenschaftlicher Nachwuchs 2017: Statistische Daten und Forschungsbefunde zu Promovierenden und Promovierten in Deutschland*; Bielefeld: wbv.

Kreckel, Reinhard. 2010. Karrieremodelle an Universitäten Im Internationalen Vergleich. In *Der Lange Weg zur Professur. Berufliche Perspektiven für Nachwuchswissenschaftler/innen*. Edited by Borgwardt Angela. Berlin: Bibliothek Friedrich Ebert Stiftung.

Kreckel, Reinhard. 2011. Universitäre Karrierestruktur Als Deutscher Sonderweg. In *Traumjob Wissenschaft? Karrierewege in Hochschule und Forschung*. Edited by Himpele Klemens, Keller Andreas and Ortmann Alexandra. Bielefeld: Bertelsmann, pp. 47–60.

Kyvik, Svein, and Mari Teigen. 1996. Child Care, Research Collaboration, and Gender Differences in Scientific Productivity. *Science, Technology, & Human Values* 21: 54–71.

Landry, Réjean, Namatie Traore, and Benoît Godin. 1996. An Econometric Analysis of the Effect of Collaboration on Academic Research Productivity. *Higher Education* 32: 283–301. [CrossRef]

Lee, Sooho, and Barry Bozeman. 2005. The Impact of Research Collaboration on Scientific Productivity. *Social Studies of Science* 35: 673–702. [CrossRef]

Lind, Inken, and Andrea Löther. 2007. Chancen Für Frauen in Der Wissenschaft—Eine Frage Der Fachkultur? Retrospektive Verlaufsanalysen Und Aktuelle Forschungsergebnisse. *Schweizerische Zeitschrift für Bildungswissenschaften* 29: 249–72.

Link, Albert N., Christopher A. Swann, and Barry Bozeman. 2008. A Time Allocation Study of University Faculty. *Economics of Education Review* 27: 363–74. [CrossRef]

Lutter, Mark, and Martin Schröder. 2014. *Who Becomes a Tenured Professor, and Why? Panel Data Evidence from German Sociology, 1980–2013*. MPIfG Discussion Paper 14/19. Köln: Max-Planck-Institut für Gesellschaftsforschung.

Metz-Göckel, Sigrid, Kirsten Heusgen, Christina Möller, Ramona Schürmann, and Petra Selent. 2014. *Karrierefaktor Kind: Zur Generativen Diskriminierung im Hochschulsystem*. Opladen: Budrich.

Mottaz, Clifford J. 1986. An analysis of the relationship between education and organizational commitment in a variety of occupational groups. *Journal of Vocational Behavior* 28: 214–28. [CrossRef]

Muthén, Linda K., and Bengt O. Muthén. 2004. *Mplus User's Guide: Statistical Analysis with Latent Variables: User's Guide*. Los Angeles: Muthén & Muthén.

Neugebauer, Karla M. 2006. Keeping Tabs on the Women: Life Scientists in Europe. *PLoS Biology* 4: e97. [CrossRef] [PubMed]

Plümper, Thomas, and Frank Schimmelfennig. 2007. Wer Wird Prof—Und Wann? Berufungsdeterminanten in Der Deutschen Politikwissenschaft. *Politische Vierteljahresschrift* 48: 97–117. [CrossRef]

Rossiter, Margaret W. 1993. The Matthew Matilda Effect in Science. *Social Studies of Science* 23: 325–41. [CrossRef]

Sarsons, Heather. 2017. *Interpreting Signals in the Labor Market: Evidence from Medical Referrals*. Working Paper. Cambridge: Harvard University.

Schubert, Frank, and Sonja Engelage. 2011. Wie Undicht Ist Die Pipeline? Wissenschaftskarrieren Von Promovierten Frauen. *KZfSS Kölner Zeitschrift für Soziologie und Sozialpsychologie* 63: 431–57. [CrossRef]

Sheltzer, Jason M., and Joan C. Smith. 2014. Elite Male Faculty in the Life Sciences Employ Fewer Women. *Proceedings of the National Academy of Sciences USA* 111: 10107–12. [CrossRef] [PubMed]

Sidhu, Reena, Praveen Rajashekhar, Victoria L. Lavin, Joanne Parry, James Attwood, Anita Holdcroft, and David S. Sanders. 2009. The Gender Imbalance in Academic Medicine: A Study of Female Authorship in the United Kingdom. *Journal of the Royal Society of Medicine* 102: 337–42. [CrossRef] [PubMed]

Sugimoto, Cassidy R., Vincent Lariviere, Chaoqun Ni, Yves Gingras, and Blaise Cronin. 2013. Global Gender Disparities in Science. *Nature* 504: 211–13.

Symonds, Matthew R. E., Neil J. Gemmell, Tamsin L. Braisher, Kylie L. Gorringe, and Mark A. Elgar. 2006. Gender Differences in Publication Output: Towards an Unbiased Metric of Research Performance. *PLoS ONE* 1: e127. [CrossRef] [PubMed]

Tscharntke, Teja, Michael E. Hochberg, Tatyana A. Rand, Vincent H. Resh, and Jochen Krauss. 2007. Author sequence and credit for contributions in multiauthored publications. *PLoS Biology* 5: e18. [CrossRef] [PubMed]

Widom, Cathy Spatz, and Barbara W. Burke. 1978. Performance, Attitudes, and Professional Socialization of Women in Academia. *Sex Roles* 4: 549–62. [CrossRef]

Winslow, Sarah. 2010. Gender Inequality and Time Allocations among Academic Faculty. *Gender & Society* 24: 769–93.