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**“Keep It Going, Girl!”  
An Empirical Analysis of Gender Differences  
and Inequalities in Computer Sciences**

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**ABSTRACT**

This article aims to investigate gender differences among German computer sciences graduates. Utilizing data from the unique Bamberg Alumnae Tracking Study, we analyze whether or not male and female graduates differ in their level of academic achievement in computer sciences. We also examine the graduates' self-perceptions of their professional skills as well as their individual career ambitions and career opportunities. The results of our empirical study show that the academic achievements of female graduates within our sample group are as good as those of male graduates. However, female graduates exhibit lower self-belief in their professional skills, partly because lower-achieving male graduates still display very high professional self-efficacy beliefs, irrespective of their previous academic achievements at university. Additionally, we find differences in men's and women's career ambitions and career opportunities in computer sciences. The career ambitions and career opportunities of male graduates depend less on their academic achievements at university, whereas female graduates have to be very ambitious to be able to hold a leadership position in the same field. Overall, we interpret these findings as indicative of the presence of gender stereotypes within computer sciences.

**KEYWORDS**

computer sciences; academic achievement; professional self-efficacy beliefs; career ambitions; career opportunities; gender equality

## **“Keep It Going, Girl!” An Empirical Analysis of Gender Differences and Inequalities in Computer Sciences**

### **INTRODUCTION**

Compared to other European countries, the proportion of women in leadership positions in Germany is low. In 2010, only about 30% of all leadership positions were held by women (Holst, Busch & Kröger, 2012). At only 7%, the share of leadership positions filled by women is even lower in the Information Technology (IT) sector (Bitkom, 2015; Hoppenstedt Branchenmonitor, 2012). Of course, one major reason for the low proportion of women working in leading positions in IT is that the proportion of women working in such occupations is generally low (Bitkom, 2015). However, empirical evidence shows that in general—and especially in male-dominated occupations such as computer sciences—women seem to have reduced career prospects (Abele, 2003; Abele, Volmer & Spurk, 2012; Koch, D’Mello & Sackett, 2015; Trübswetter, Hochfeld, Kaiser & Schraudner, 2014). Interestingly, it is particularly these industries that suffer from a severe lack of highly skilled personnel in Germany (Bundesagentur für Arbeit, 2016; Rechsteiner, 2016). Therefore, it is important to understand what factors hinder women wanting to enter leading positions in computer sciences in Germany and how the activation of the highly educated female workforce can be realized more effectively within this sector of the industry.

This article aims to shed light on this question by utilizing a data source unique to Germany, namely the Bamberg Alumnae Tracking Study. This study offers detailed information on students and graduates of the Faculty of Information Systems and Applied Computer Sciences at Bamberg University. For the purpose of this article, which aims to investigate gendered career opportunities and career ambitions in computer sciences, we make use of the graduates’ subsample of the Bamberg Alumnae Tracking Study. Our core interest is to understand and analyze the significance of gender differences in academic performance and graduates’ self-perception of professional skills, as well as the career ambitions and opportunities available to graduates wanting to pursue a leadership role in computer sciences. In particular, we are interested in whether or not the academic performance of a given individual at university, and their self-perception of professional skills, have differing impacts on male and female graduates.

The next section discusses the general theoretical framework underlying our empirical study. Proceeding, we introduce our research design, data, and methods before reporting the results of our multivariate analyses. Our article then concludes with a short summary and discussion of our findings.

### **THEORETICAL FRAMEWORK**

In this section, we discuss the theoretical assumptions underlying our empirical analysis of the gendered career opportunities and career ambitions of graduates studying computer sciences. Of course, the career opportunities available to, and aspirations of, any given graduate are the result of a complex interplay of personal, social, private, and societal factors. However, for the purpose of our study, we pay

particular attention to the role of the individuals' self-perception of professional skills on the one hand, and their "objective" skills on the other.

Despite the fact that women have become increasingly successful in the educational systems of almost all Western countries and have even surpassed men in terms of educational attainment (van Bavel, 2012; DiPrete & Buchmann, 2013; Vincent-Lancrin, 2008), clear gender differences in the labor markets of modern societies persist. Women tend to earn less than men (Bach, 2014; Bundesministerium für Familie, Senioren, Frauen und Jugend, 2010); men and women concentrate in quite different occupations and sectors (Hachmeister, Harde & Langer, 2007; Studienwahl.de, 2012); the careers of women are strongly influenced by family events—in particular child birth (Walther & Lukoschat, 2008; Ziegler, Graml & Weissenrieder, 2015); and, especially in countries like Germany with quite conservative gender ideologies, the percentage of women working part-time is high (OECD, 2013; Schulze Buschoff & Rückert-John, 1999).

In order to explain such inequalities between the careers of men and women, theoretical concepts often refer to the existence of gender stereotypes, stereotype threat (Spencer, Steele & Quinn, 1999; Steele, 1997) and gender roles (Abele, 2003; Athenstaedt, 2002; Athenstaedt & Alfermann, 2011; Athenstaedt & Mikula, 2008). The underlying theoretical assumption of such models implies that deeply rooted societal gender roles and gender stereotypes have an impact on the decision-making and behavior of both employers and employees, with the effect that the career opportunities and career ambitions of women differ systematically from those of men (Boye, 2009; Claffey & Mickelson, 2009; Russo, 1976).

We want to begin with a discussion of how gender roles and gender stereotypes affect the recruitment strategies of employers. To fill jobs—in particular strategically important jobs, such as those with leadership responsibilities—employers try to avoid misallocations. To reduce the risks of misallocations, employers look for effective ways to evaluate the potential productivity of job candidates, for example by making use of specific individual signals (Spence, 1973), such as gender and skillset. Candidates are then ranked according to these observable signals and those candidates displaying the highest potential are afforded the greatest opportunities to be recruited for a specific post. As a result, men enjoy better career opportunities than women, not least because the employment histories of men tend to be very stable and less influenced by family-related employment interruptions. Therefore, it seems more "rational" for employers to invest in men (Binder, 2007). Additionally, gender stereotypes support the idea that employers may perceive men as more "able" to take over strategically important positions—such as jobs with leadership responsibilities—because the personal traits of successful leaders are usually male-connoted. For example, jobs with leadership responsibilities are said to demand strong self-assertion and will—attributes usually ascribed to men (Abele, Uchronski, Suitner & Wojciszke, 2008). Of course, the recruitment practices of employers are influenced by more than simply the gender of the candidate. It is common practice for employers to make use of information such as the candidates' educational certificates to rate their potential "objective" abilities and skills (Velasco, 2012). We

therefore expect graduates attaining high academic results at university to enjoy better career opportunities than those who do not (Abele & Spurk, 2009b; Eccles & Wigfield, 2002; Spurk & Abele, 2014).

It seems reasonable to expect that academic performance has a similar impact on the career prospects of both males and females alike. However, research and theory on stereotype (threat) suggest otherwise (Abele & Spurk, 2009a, 2009b; Spencer et al., 1999). As a result, we expect that the opportunities for men to be employed in leadership positions in computer sciences depend less on their previous performances at university (Abele-Brehm & Stief, 2004; Mischau, Langfeldt, Griffiths & Reith, 2012; Reuben, Rey-Biel, Sapienza & Zingales, 2010). Thus, simply by being male, and irrespective of their "objective" abilities, male graduates might fulfil the stereotypical requirements needed to fill a leadership position. In contrast, we expect that it requires much more for a female graduate to be employed in a leadership position. For example, it might require excellent university grades and the very highest career ambitions.

So far, our discussion has focused solely on the employer. However, culturally and societally shaped gender roles and gender stereotypes of course also affect the graduates themselves—their behavior, life planning, and self-perception (Aigner & Cain, 1977; Arrow, 1973; Phelps, 1972). In his Social Cognitive Theory, Bandura (1986, 1997) discussed the role of self-efficacy beliefs. His general argument is that confidence in one's own abilities strongly influences the actions and behavior of individuals. Bandura's general model has been applied to many different fields. Among others, the self-efficacy theory has been used to understand gender inequalities in male-dominated occupations, such as Science, Technology, Engineering, and Mathematics (STEM; Abele, 2002, 2003; Abele & Spurk, 2009a; Abele et al., 2012; Brauner, Leonhardt, Ziefle & Schroeder, 2010; Kosuch, 2010; Lent, Brown & Hacklet, 1994, 2000; Lent, Brown & Larkin, 1986). Gender stereotypes with deep cultural roots can be expected to have a major influence on how men and women perceive themselves and rate their own skills. We therefore assume that the confidence exhibited by the graduates in our study with regard to their professional skills in computer sciences differs systematically (Berdousis & Kordaki, 2015; Hannover 2007; Hannover & Bettge, 1993; Heatherington et al., 1993; Kessels, 2014; Skorepa & Fuhrmann, 2009; Zimmer, Burba & Rost, 2004). In contrast to male graduates, we expect female graduates to display significantly lower belief in their professional self-efficacy. Additionally, we expect that their self-perception of professional skills strongly depends on their "objective" abilities—that is, their academic achievements at university. Computer sciences are perceived as a male domain and therefore male graduates should display a generally high self-perception of professional skills irrespective of how well they performed during their studies, simply because they are male.

However, we do not only expect to observe gender differences between men and women with regard to their self-perception of professional skills, but also with regard to their career ambitions. For various reasons, we would expect the career ambitions of the male graduates in our study to be significantly higher than those of the female graduates. Due to existing gender stereotypes, men perceive

themselves as the “breadwinners” of the family, and as a result it can be expected that men might display higher career ambitions than women. Furthermore, for men, high career ambitions do not conflict with their role as the caregivers of the family and thus the need to reconcile both family and work life. Additionally—and again due to existing gender stereotypes and roles—we expect men’s career ambitions not to be so dependent on their academic performance at university, nor on their self-perception of professional skills. Rather, the career ambitions of men are presumed to be generally high, while women’s career ambitions are presumed to be strongly influenced by previous academic performance and their self-perception of professional skills.

### **RESEARCH DESIGN, DATA, AND METHODS**

For the purpose of our study, we make use of the unique German data set, the Bamberg Alumnae Tracking Study. From 2012 to 2015, this study collected data on the students and graduates of the Faculty of Information Systems and Applied Computer Sciences at Bamberg University. In total, about 500 students and graduates participated in the study. However, since we are interested in gender differences specifically in the context of the labor market, we make use only of the graduate subsample. The Bamberg Alumnae Tracking Study collected data in the years 2013, 2014, and 2015. Data on professional self-efficacy beliefs, however, was only collected in the years 2014 and 2015. Therefore, we further restricted our analytical sample to respondents that participated in the second and third years of the Bamberg Alumnae Tracking Study. Based on these specifications, our analytical sample includes 103 individuals.

Our research design consists of three steps. In the first step, we focus on gender differences both in the “objective” skills and self-perception of professional skills of the graduates. To operationalize graduates’ “objective” skills, we made use of information on their academic achievements at university—specifically, final grades. To operationalize the graduates’ self-perception of professional skills, we made use of a specific item of the Bamberg Alumnae Tracking Study in which respondents were asked to rate whether or not they possessed the skills needed in computer sciences<sup>1</sup>. Although we did not have any specific expectations with regard to gender differences in their “objective” abilities (i.e. their academic performance at university), we hypothesized that significant gender differences in self-perception of professional abilities might exist<sup>2</sup>. In the second step of our empirical study, we examined the career ambitions of men and women by analyzing whether or not graduates value a career as an important life goal. A specific question of the Alumnae Tracking Study asked participants if making a career is important to them. On a 5-point scale, ranging from “not important at all” to “very important”, graduates were able to rate their career ambitions. We grouped respondents that reported that making a career is “important” or “very important” to them into one category, and compared them in our analyses to graduates that reported average or low career ambitions. In the third and final step of our study, we analyzed whether or not male and female graduates differ in their career opportunities. To operationalize graduates’ career opportunities, we made use of a specific question of the Bamberg Alumnae Tracking Study in which graduates were asked if they held a job with leadership responsibilities in computer sciences<sup>3</sup>. Based on this question,

we were able to differentiate between graduates working in jobs with leadership responsibilities and those who were not. We estimate a series of logistic regression models and present results on gender differences in: (a) graduates' academic performance at university; (b) graduates' self-perception of professional skills in computer sciences; (c) graduates' career ambitions; and (d) graduates' opportunities to be employed in a job with leadership responsibilities.

Table 1 summarizes the main characteristics of our sample. Our core independent variable is the gender of the respondent. To understand the role of gender-specific effects on the academic performance of graduates, their self-perception of professional skills, and career ambitions, we additionally estimated interactions between the respondents' gender and the corresponding covariates. Our multivariate models control additional variables, such as the year of graduation and family status. However, for the sake of simplicity, we do not present the estimated effects of these control variables, but "only" report those additional variables we controlled in the presented models. Detailed information on all additional control variables is available on request from the authors.

*Table 1: Core characteristics of our sample*

	n	Per cent
Total	103	100.00
Gender		
Male	86	83.50
Female	17	16.50
Academic achievements at university		
Excellent	39	37.86
Good or worse	64	62.14
Self-perception of professional skills		
High	91	88.35
Low or medium	12	11.65
Career ambitions		
Very high or high	50	48.54
Average or low	53	51.46
Holding a leadership position		
Yes	52	50.49
No	51	49.51

*Source: Our own calculations based on data from the Bamberg Alumnae Tracking Study.*

Since there has been a growing criticism on the reliability of regression coefficients and odds ratios in logistic regression models (Mood, 2010), we follow the current state of research and report Average Marginal Effects (AME) as well as Predictive Margins (PM). Besides a higher reliability, a positive side effect of predictive margins and average marginal effects is that they permit the presentation of results

of logistic regressions in a far more comprehensible and easily understood manner. Predictive margins can be interpreted as average probabilities. Average marginal effects can be interpreted as percentage point differences between the estimated predictive margins allowing testing in order to ascertain whether or not differences in the estimated predictive margins are statistically significant.

## RESULTS

### Do Male and Female Graduates Differ in Academic Performance and Self-Perception of Professional Abilities?

In the first step of our empirical study, we investigate whether or not male and female graduates in computer sciences differ in their academic achievements and self-perception of professional skills. The results of our multivariate analyses are reported in Table 2.

*Table 2: Gender differences in graduates' academic achievements at university and self-perception of professional skills (logistic regression models).*

	High achievement at university (Model 1)		High professional self-efficacy beliefs (Model 2)	
	AME	PM	AME	PM
Men	Ref.	37.77	Ref.	92.50
Women	0.53	38.30	-20.27**	72.23
n	103			
Log likelihood	-67.45		-28.63	

*Source: Our own calculations based on data from the Bamberg Alumnae Tracking Study.*

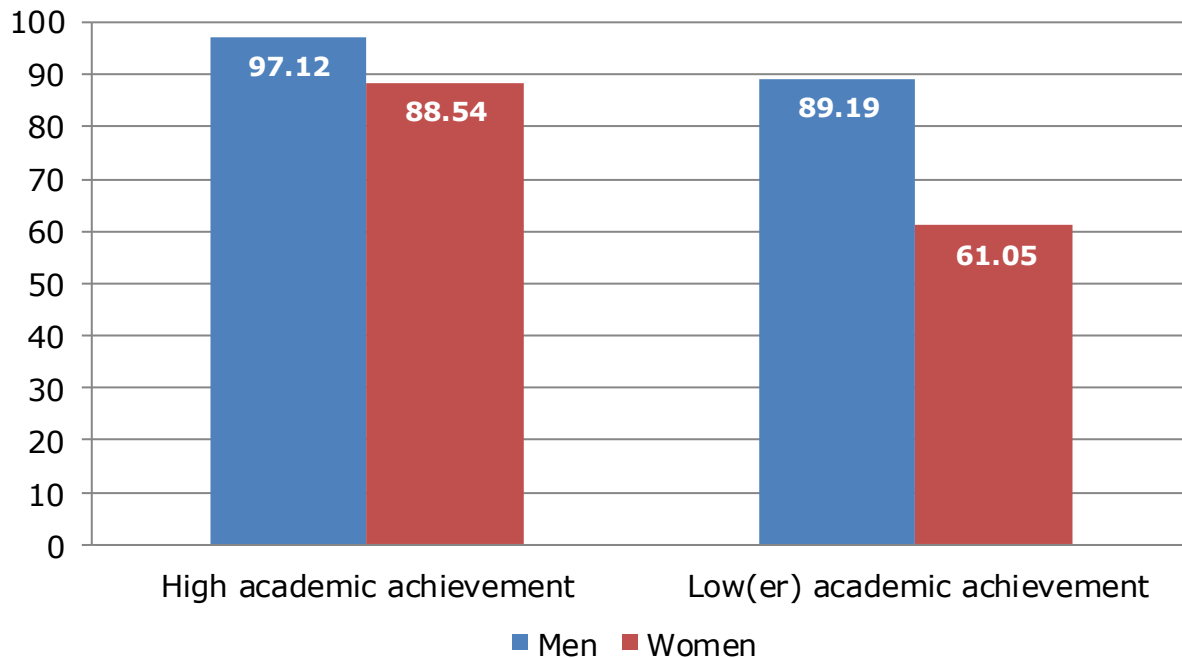
*Notes: AME = Average Marginal Effects (expressed as percentage points), PM = Predictive Margins (expressed as percentages). Besides gender, both models additionally control for year of graduation; Model 2 has additional controls for respondents' academic achievements at university and family status.*

The estimates of Model 1 indicate that *not* significant differences in the academic performance of the male and female respondents of our study exist. Among both, the average proportion of students who graduated from university with an excellent degree in computer sciences is approximately 38%. Hence, the female graduates in our sample can be considered academically as "able" as their male counterparts. This is an important result that has to be kept in mind because, as a consequence, gender differences in our graduates' self-perception of professional skills, career opportunities, and career ambitions cannot be attributed to differences between the objective abilities of men and women.

However, even though the women in our sample passed their university exams as well as the men, clear gender differences exist in our respondents' self-assessment of their abilities in computer sciences (Model 2). While almost all male respondents

(on average 92.5%) believe they possess a high level of professional skill in computer sciences, only about 72% of the female respondents felt similar. As the estimated average marginal effect shows, this difference of 20.27 percentage points between male and female graduates is statistically significant.

To understand if gender-specific differences in the effect of academic achievement at university on graduates' self-perception of skills in computer sciences exist, we introduced an interaction between graduates' gender and their academic achievements in an additional model. The corresponding results are presented in Figure 1.



*Source: Our own calculations based on data from the Bamberg Alumnae Tracking Study.*

*Notes: Predictive margins (expressed as percentages) derived from a logistic regression model that controls for respondents' gender, year of graduation, family status, academic achievements at university, and the interaction between respondents' gender and academic achievements at university.*

*Figure 1: Gender-specific effects of graduates' academic achievement at university on their self-perception of skills in computer sciences.*

Our results indicate that gender-specific differences in the effect of graduates' academic achievements at university on their professional self-efficacy beliefs exist. As expected, the self-perception of professional skills by men depend little on their academic achievements at university. Although the share of graduates reporting high professional self-efficacy beliefs is somewhat higher among men who graduated from university with excellent grades than among lower-achieving men, almost *all* of the male graduates in our sample (that is, on average, 89.19% and 97.12%) report high professional self-efficacy beliefs in computer sciences.



Additional analyses revealed that the difference of 7.93 percentage points in professional self-efficacy beliefs between high-achieving and lower-achieving men is *not* significant.

In contrast, women’s self-perception of professional skills depends significantly on their previous academic performance at university. While almost 90% of the high-achieving female graduates believe themselves to possess high professional abilities in computer sciences, this is the case for only about 60% of the women attaining lower academic achievements at university. Additional analyses have shown that the difference of 27.49 percentage points between high- and lower-achieving female graduates is statistically significant.

Our results can thus be summarized as follows: while women’s self-perception of skills in computer sciences depends significantly on their previous academic performance at university, this is not the case for men. Male graduates have a very high self-perception of their abilities in computer sciences, no matter how well they performed at university.

**Do Male and Female Graduates Differ in Their Career Ambitions?**

In the second step of our empirical study, we are interested in gender differences in graduates’ career ambitions. In the Bamberg Alumnae Tracking Study, participants were asked if a career is an important life goal. The results of our multivariate analyses are presented in Table 3. Again, we only report gender effects, although we examined additional factors in our logistic regression model. As before, we present average marginal effects and predictive margins.

*Table 3: Gender differences in graduate career ambitions (logistic regression models).*

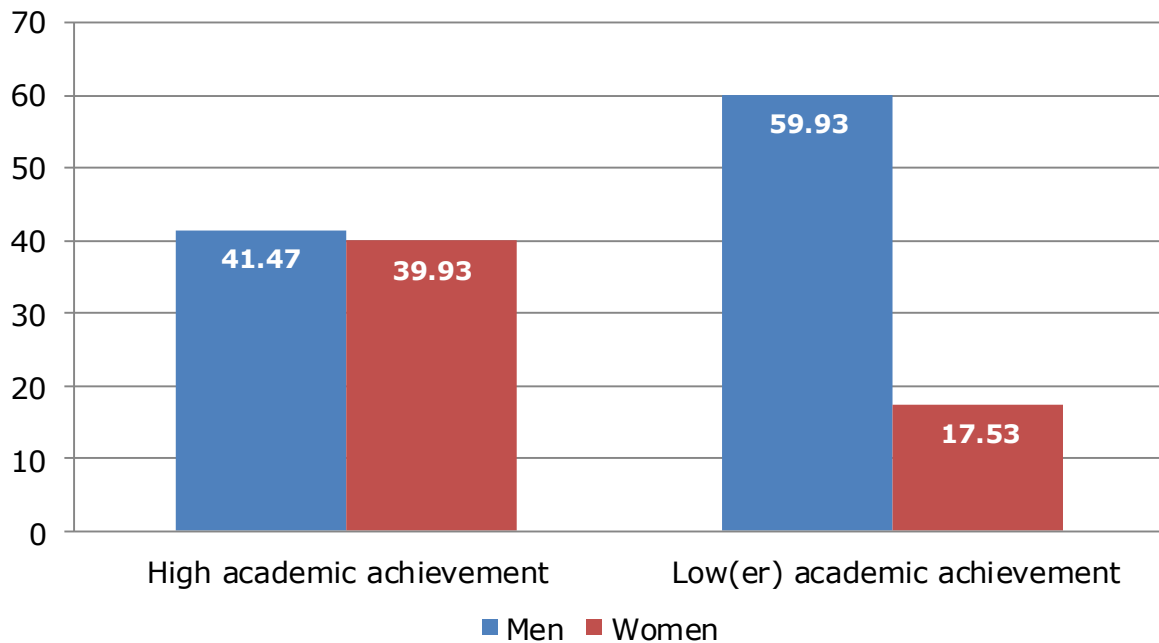
	AME	PM
Men	Ref.	52.72
Women	-25.09**	27.63
n	103	
Log likelihood	-67.08	

*Source: Our own calculations based on data from the Bamberg Alumnae Tracking Study.*

*Notes: AME = Average Marginal Effects (expressed as percentage points), PM = Predictive Margins (expressed as percentages). Besides gender, the model additionally controls for respondents’ year of graduation, family status, academic achievements at university, and self-perception of professional skills.*

As expected, we find substantial differences in the career ambitions of male and female graduates in computer sciences. While more than half (52.72%) of the male graduates report that a career is important or highly important to them, this is the case for only about one quarter (27.63%) of the female graduates. The reported average marginal effect indicates that the difference of 25.09 percentage points in career ambitions between men and women is statistically significant.

Again, we are interested in gender-specific effects and therefore introduced various interaction terms into our model. Figure 2 presents results on the gender-specific effect of graduates' academic achievements at university on their career ambitions. Interestingly, men who did *not* achieve excellent grades at university constitute the group reporting the highest career ambitions. Almost 60% of the men who had *not* been high achievers at university report that building a career is important to them, compared to 41.47% of the male graduates with excellent grades at university. Additional analyses revealed that this difference in the career ambitions of male graduates with high academic achievements at university and male graduates with low(er) academic achievements is statically significant.



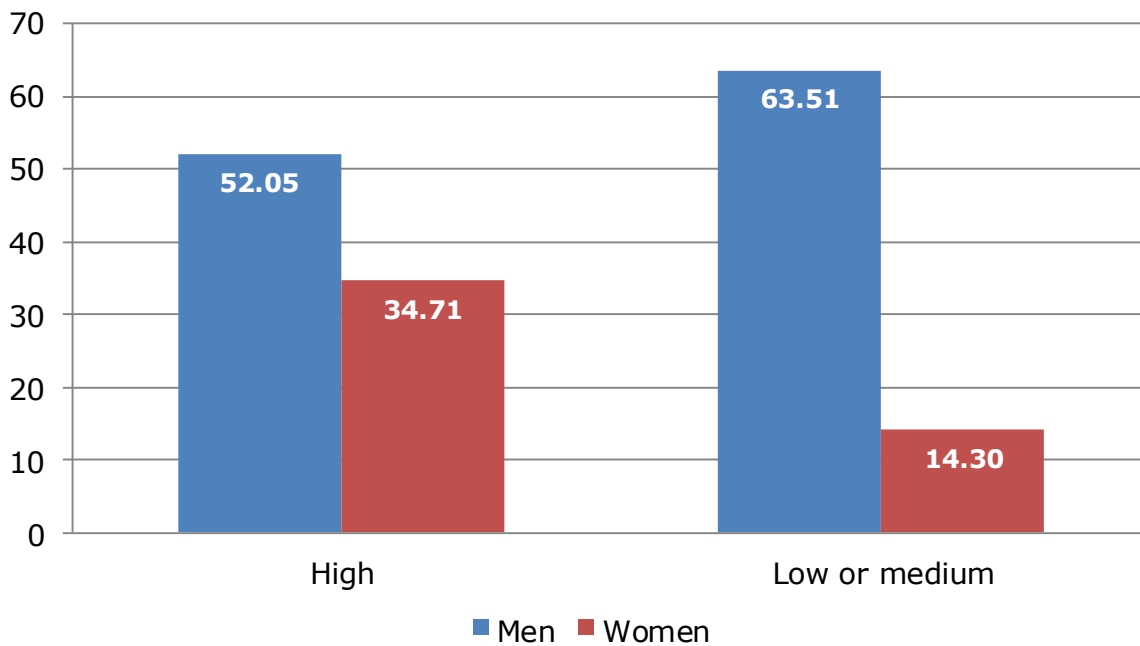
Source: Our own calculations based on data from the Bamberg Alumnae Tracking Study.

Notes: Predictive margins (expressed as percentages) derived from a logistic regression model that controls for respondents' gender, year of graduation, family status, self-perception of professional skills, academic achievements at university, and the interaction between respondents' gender and academic achievements at university.

Figure 2: Gender-specific effects of graduates' academic achievements at university on career ambitions.

With regard to gender differences, we do not find any statistically significant differences between the career ambitions of male and female graduates with high academic achievements at university. Among both high-achieving men *and* high-achieving women, about 40% report that a career is important to them. However, significant differences between men and women who did *not* graduate from university with excellent grades in computer sciences exist. While low(er) achieving female graduates display very low career ambitions, as previously noted, this is not the case for low(er) achieving male graduates.

Figure 3 presents the results of the gender-specific effect of graduates' self-perception of professional skills on their career ambitions. Again, it is surprising that male graduates with low or average professional self-efficacy beliefs report the highest career ambitions. However, the difference in comparison to male graduates with high professional self-efficacy beliefs is statistically not significant. For women, however, the effect of professional self-efficacy beliefs operates in the expected direction: female graduates displaying low or average professional self-efficacy beliefs report substantially lower career ambitions than female graduates with high professional efficacy beliefs. Again, female graduates with low or average professional self-efficacy beliefs in computer sciences differ significantly from male graduates with low or average professional self-efficacy beliefs.



*Source: Our own calculations based on data from the Bamberg Alumnae Tracking Study.*

*Notes: Predictive margins (expressed as percentages) derived from a logistic regression model that controls for respondents' gender, year of graduation, family status, academic achievements at university, self-perception of professional skills, and the interaction between respondents' gender and self-perception of professional skills on career ambitions.*

*Figure 3: Gender-specific effects of graduates' self-perception of professional skills*

Taken together, we therefore conclude that women's academic performance at university and their professional self-efficacy beliefs have the predicated impact on career ambitions. However, for men, the effects of previous academic performance and self-perception of professional skills surprisingly work in the opposite direction. Low(er) achieving men and men with low or average professional self-efficacy beliefs report the highest career ambitions.

**Do the Career Opportunities Differ for Male and Female Graduates?**

In the third and final step of our empirical study, we focus on gender differences in graduates’ career paths by observing their opportunities to hold a leading position. The results of our multivariate analyses are presented in Table 4. As our major interest is in gender, we report only gender effects, although we also looked for additional factors in our logistic regression models and refer to average marginal effects and predictive margins.

*Table 4: Gender differences in opportunities for graduates to work in a job with leadership responsibilities (logistic regression models).*

	AME	PM
Men	Ref.	52.04
Women	-15.92	36.12
n	103	
Log likelihood	-62.32	

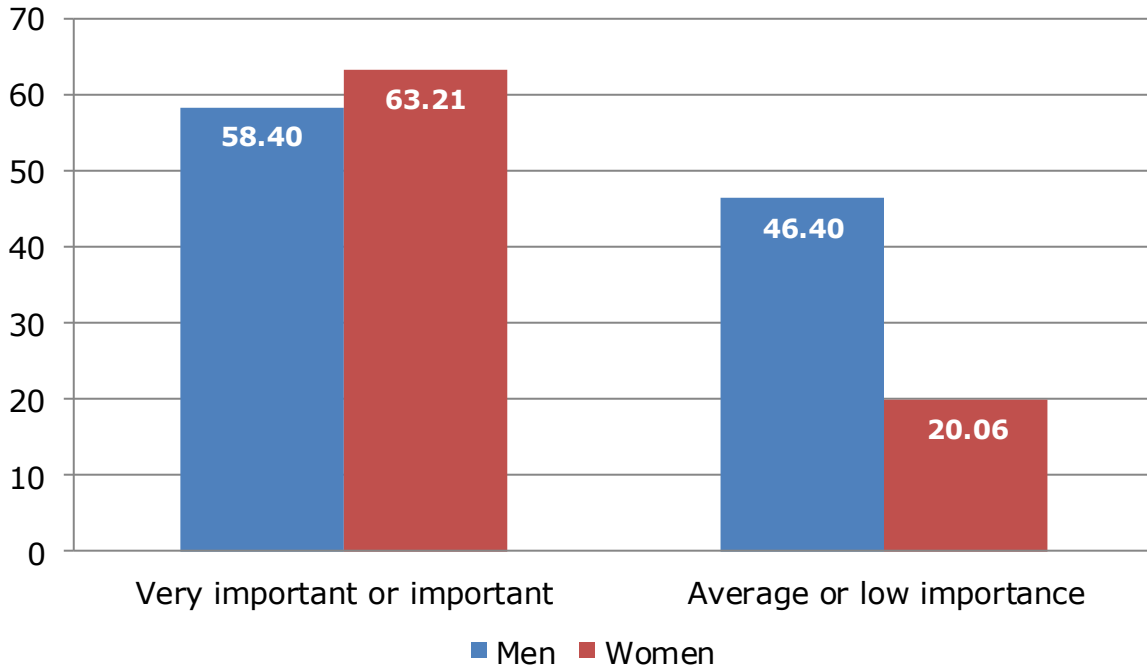
*Source: Our own calculations based on data from the Bamberg Alumnae Tracking Study.*

*AME = Average Marginal Effects (expressed as percentage points), PM = Predictive Margins (expressed as percentages). Besides gender, the model additionally controls for respondents’ year of graduation, family status, academic achievements at university, self-perception of professional skills, and career ambitions.*

Although the predictive margins indicate that male graduates are clearly more likely to hold a leadership position in computer sciences than female graduates (52.04% versus 36.12%), the estimated average marginal effect of about 16 percentage points proves not to be statistically significant. The reason for this lack of significance is likely to be related to our small sample size and should therefore not be overemphasized, in particular since the graduates in our sample are still in the early stages of their careers.

However, further investigations indicate that substantial gender-specific effects for graduates’ career ambitions exist (Figure 4). The desire to have a career is far more significant to their chances of holding a leadership position in computer sciences for female graduates than it is for male graduates. Of female employees in computer sciences that affirm the importance of a career, on average, 63.21% of them succeed in being employed in a position with leadership responsibilities compared to only 20.06% of women who do *not* say that a career is of importance to them. In contrast, for men, career ambitions are far less relevant to gaining employment in a position with leadership responsibilities within computer sciences. Even if men report that making a career is *not* important to them, 46.40% of them still hold a job with leadership responsibilities, while among women only very ambitious graduates work in a leadership position. For men, being ambitious does not exert a

significant influence on their chances to be employed in a job with leadership responsibilities.



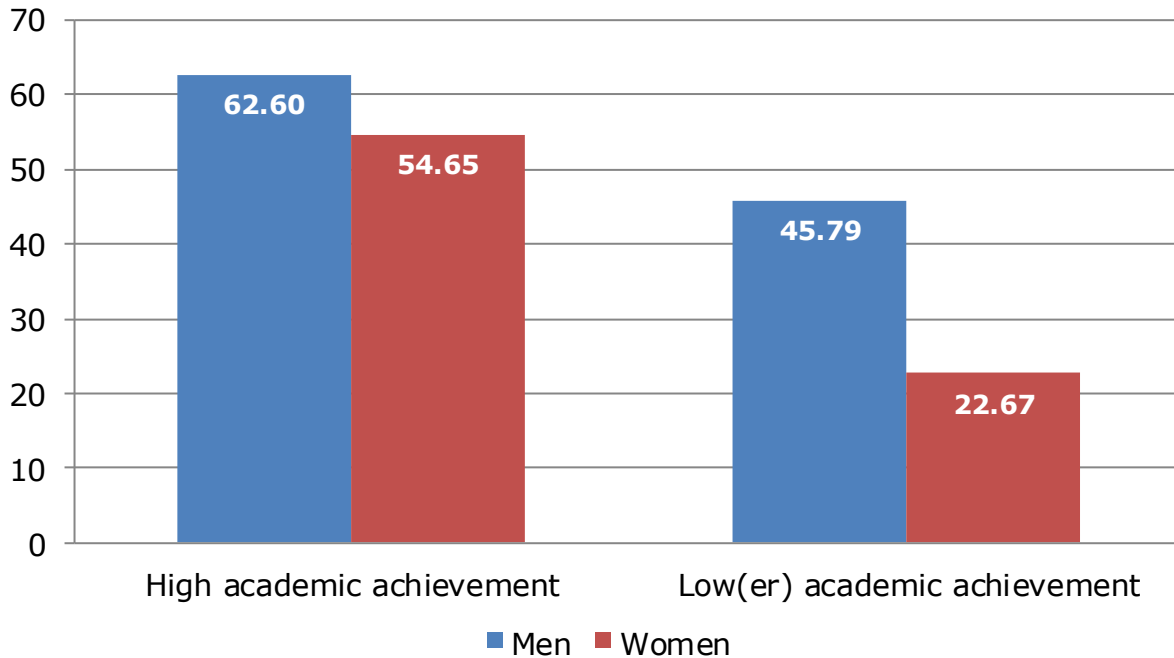
*Source: Our own calculations based on data from the Bamberg Alumnae Tracking Study*

*Notes: Predictive margins (expressed as percentages) derived from a logistic regression model that controls graduates' gender, year of graduation, family status, academic achievements at university, self-perception of professional skills, career ambitions, and the interaction between gender and career ambitions.*

*Figure 4: Gender-specific effects of career ambitions on graduates' opportunities to work in a job with leadership responsibilities.*

Moreover, we find a gender-specific effect of the graduates' final university degree (Figure 5): while both men and women with excellent academic achievements at university display higher chances of work in a position with leadership responsibilities, having attained high academic qualifications is less important for men than for women. On average, 45.79% of the men who did *not* achieve excellent grades at university are able to fill a job with leadership responsibilities in computer sciences, while this is the case for only 22.67% of the women who did not achieve excellent grades at university. Hence, and as expected, previous

academic achievements are less important to the career opportunities of men than to women.



*Source: Our own calculations based on data from the Bamberg Alumnae Tracking Study.*

*Notes: Predictive margins (expressed as percentages) derived from a logistic regression model that controls for respondents' gender, year of graduation, family status, self-perception of professional skills, career ambitions, academic achievements at university, and the interaction between gender and academic achievement at university.*

*Figure 5: Gender-specific effects of academic achievements at university on graduates' chances to work in a job with leadership responsibilities.*

### **Outlook**

Since the graduates in our sample are still very young and consequently are still at an early stage of their careers, we would like to close our empirical study with a look to the future. The Bamberg Alumnae Tracking Study did not only ask graduates whether or not they currently work in a job with leadership responsibilities in computer sciences, but it also well whether not yet employed in a leadership position if they would like to work in such a job in the future. Hence, we are not only able to investigate gender differences in the opportunities to *hold* a job with leadership responsibilities, but we are also able to investigate opportunities to *wish* to work in such a position. Table 5 presents the results of a corresponding logistic regression model.

*Table 5: Gender differences in graduates' opportunities to work in a job with leadership responsibilities or aspirations towards a job with leadership responsibilities (logistic regression models).*

	AME	PM
Men	Ref.	65.47
Women	-26.95**	38.52
n	103	
Log likelihood	-52.00	

*Source: Our own calculations based on data from the Bamberg Alumnae Tracking Study.*

*Notes: AME = Average Marginal Effects (expressed as percentage points), PM = Predictive Margins (expressed as percentages). Besides gender, the model additionally controls for respondents' year of graduation, family status, academic achievements at university, self-perception of professional skills, and career ambitions.*

If we additionally account for future career wishes, we find a significant gender difference. Only 38.52% of the female graduates in computer sciences fill or aspire to fill a job with leadership responsibilities, compared to 65.47% of the men. Comparing these estimates with the results presented in Table 4, it becomes clear that only a very low proportion of women aspire to work in a leadership position when not already employed in one. The predictive margins for women hardly change between Table 4 and Table 5 (36.12% vs. 38.52%). In contrast, there is a clear increase of about 13.5 percentage points in men's predictive margins when we also include graduates aspiring to a leadership position in computer sciences (an increase from 52.04% in Table 4 to 65.47% in Table 5). Hence, it appears that while the career ambitions of the female graduates in our sample are satisfied, male graduates' ambitions to work in a job with leadership responsibilities were not yet fully satisfied at the time of our observation.

## **DISCUSSION AND CONCLUSIONS**

The aim of this article was to study gender differences in computer sciences. It is well known (Bitkom, 2015; Broy, Denert & Engeser, 2008; Eccles, 2007; Hill, Corbett & St. Rose, 2010; Kompetenzzentrum Technik—Diversity—Chancengleichheit, 2017) that few women decide to take up studies in STEM. The focus of our paper, however, was not to investigate gender differences in the subject choices of men and women, but rather to study whether or not men and women who successfully graduated in computer sciences differ in their academic abilities, self-perception of professional skills, career ambitions, and career opportunities. To this end, we made use of the Bamberg Alumnae Tracking Study. To the best of our knowledge this is the only German data source that permits the in-depth study of gender differences in computer sciences. Although the sample size is small, we were able to reveal important results with regard to gender differences among computer sciences graduates.

Firstly, our empirical results indicate that *no* gender differences exist in the academic performance of the graduates in the Bamberg Alumnae Tracking Study.

Hence, the female graduates of our empirical study are “objectively” as able as their male counterparts. However, despite having achieved grades at university equal to their male counterparts, the female graduates in our sample exhibit a significantly lower self-perception of their professional abilities. Additional analyses indicate that this gender difference is partly driven by the fact that the self-perception of professional skills in computer sciences for women depends on their previous academic achievements at university, while this is not the case for men. Male graduates report very high professional self-efficacy beliefs in computer sciences in general, irrespectively of how well they performed at university. This finding could be interpreted as a sign of gender-specific stereotypes. It may be due to the fact that, in Germany, computer sciences are male-dominated and technical skills are usually attributed to men (Broy et al., 2008; Schmid, Gärtig-Daug & Förtsch, 2015). Therefore, men seem to perceive themselves as skilled, in general, while women’s self-perception of professional skills in computer sciences is influenced by their previous academic achievements at university.

In addition, our empirical study reveals significant gender differences in the career ambitions of graduates. The career ambitions of female graduates in computer sciences are significantly lower than those of male graduates. On average, more than half of the men in our sample group report that having a career is important to them, while this is true for only a quarter of the female graduates. Interestingly, men who did *not* perform excellently at university report the highest career ambitions. This could be a sign of compensatory effects among lower-achieving men. For women, however, the effect of academic performance is as expected: the better female graduates performed at university, the higher their career ambitions are, whereas the career ambitions of female graduates who did not achieve excellent grades at university are very low.

Although the main effect of the graduates’ gender has not proven to be statistically significant, male graduates tend to enjoy better career opportunities in computer sciences. Their chance to be employed in a leadership position is about 16 percentage points higher than for female graduates. About 50% of the male graduates in our sample group hold a leadership position in computer sciences, compared to only one third of the female graduates. Furthermore, a gender-specific effect of the graduates’ career ambitions on the chances to be employed in a job with leadership responsibilities seems to exist. For female graduates, high career ambitions are a very important prerequisite to holding a leadership position in computer sciences. For men, however, career ambitions are far less relevant to the opportunity to be employed in a job with leadership responsibilities. Almost half of the men who exhibited low career ambitions were employed in a job with leadership responsibilities in computer sciences, while this is the case for only about one fifth of the women. Our analyses indicate overall that men depend less on their academic achievements at university to build (or aspire to) a career in computer sciences. In short: in stark contrast to women, men end up in (or aspire to) a leading position in computer sciences irrespectively of how well they performed at university or how ambitious they are.

Even though our study is hopefully able to shed more light on gender differences and gender inequalities active in the field of computer sciences, some limitations



still exist. The most important limitation of our study is probably the small sample size. Therefore, it is important to validate our findings on the basis of larger data sets. Additionally, it was beyond the scope of our study to investigate how exactly firms and employers might support women's careers in computer sciences more successfully. Based on our empirical results, there seem to be different factors at work in the career opportunities and career ambitions of men and women in computer sciences. Besides collecting data on students and graduates, the Bamberg Alumnae Tracking Study additionally surveyed companies. Indeed, gender-specific human resource strategies seem to support women's career opportunities and career ambitions in computer sciences, and the Bamberg Alumnae Tracking Study has been able to identify some examples of best practice (Förtsch, Gärtig-Daug & Schmid, 2015). In particular, one IT company with almost 50,000 employees stood out. This company introduced various measures supporting the careers of female employees, for example by offering supervision programs to women, and coaching them for internal career programs. However, how far such measures are actually able to directly affect women's self-perception of skills, career ambitions, and career opportunities has to be the topic of future research and requires data that links employee and employer data.

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### **ENDNOTES**

- 1 Of course, a variety of ways to operationalize professional self-efficacy beliefs exist (Abele, Stief & Andrä, 2000; Schwarzer, 1993), and the Bamberg Alumnae Tracking Study also collected various items on individuals' professional self-efficacy beliefs. However, the item we use is the most distinct measure, both theoretically and empirically.
- 2 Due to our small sample size, we had to create dummy variables for both graduates' "objective" abilities and their self-perception of professional skills. For "objective" abilities, we differentiate between graduates who achieved excellent grades at university and those achieving more modest results. With regard to the graduates' self-perception of professional skills, we differentiate between participants reporting high or very high professional self-efficacy beliefs and those reporting only average or lower professional efficacy beliefs.
- 3 It is a specificity of the German labor market that vocational certificates are of particular importance to individuals seeking specific jobs. In contrast to most other modern societies, Germany is well known for having highly occupational specific and segregated labor market structures (Müller & Shavit, 1998). As a result, usually only those employees with the "right" vocational certificate have access to qualified jobs, such as jobs with leadership responsibilities in computer sciences.

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