Essays on Higher Education in Germany

Inaugural-Dissertation
zur Erlangung des Grades
Doctor oeconomiae publicae (Dr. oec. publ.)
an der Ludwig-Maximilians-Universität München

2018

vorgelegt von

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Promotionsabschlussberatung: 30. Januar 2019

Tag der mündlichen Prüfung: 22.01.2019

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Acknowledgments

This dissertation would not have been possible without the steady support of numerous people. First and foremost, I would like to thank my supervisor, Joachim Winter, for his valuable advice, comments, and support. Thanks also go to my second supervisor, Uwe Sunde, and to Florian Englmaier for being the third member of my thesis committee.

I would further like to thank my co-author Markus Nagler; working with him was a great pleasure and I have learned much through this collaboration. In addition, I am grateful to my fellow graduate students Nadine Geiger, Katharina Schüßler, and Michael Specht for discussing research ideas, problems, and papers as well as for their encouragement and their friendship.

Special thanks also go to Silke Englmaier for her continuous support and understanding and the freedom to focus on my research whenever necessary. Many thanks are also due to my student assistants Agnieszka, Hannah, and Sebastian for apparently endless data research, as well as to Heiko Bergmann and Nina Storfinger from the Research Data Centre in Munich, where I carried out almost all the empirical work for this thesis.

Finally, I am greatly indebted to my family for their endless love, motivation, and patience and for always believing in me.

Sarah Weise

Munich, September 2018

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Preface

Higher education has a long tradition in Germany. The oldest universities in Germany are among the oldest worldwide and had already been founded by the late Middle Ages, e.g., Heidelberg University in 1386 and the University of Cologne in 1388.[1] But of course only a handful of highly privileged students were able to attend universities at that time, and access to higher education remained restricted to a favored and select elite for the next centuries. By 1900 the share of a given birth cohort enrolling in universities still was no higher than 1 percent, and by the beginning of the 1930s it had only slightly increased to around 2 percent (Rüegg, 2004, p. 202). However, since the end of World War II until today there has been a sharp increase in the share of the population attending higher education. Nowadays more than 50 percent of a birth cohort in the respective university entry age enroll in higher education in Germany.[2] Overall, 2.8 million students were enrolled in university in Germany in the winter term 2016-17 (Hochschulrektorenkonferenz, 2017, p. 7).

This dissertation consists of three chapters on different topics of tertiary education and policy reforms that have influenced the German higher education landscape in recent years. While the first chapter focuses on the effects of the Bologna reform on educational outcomes of students in Germany, the remaining chapters analyze university students' decisions of where and what to study.

[1] Other universities in Germany founded before 1500 include Leipzig University (1409), the University of Rostock (1419), the University of Greifswald (1456), the University of Freiburg (1457), LMU Munich (1472), and the University of Tübingen (1477).

[2] Share of a birth cohort at university entry age that enroll in higher education in Germany since 2010: 2010 - 46.0 percent; 2011 - 55.6 percent; 2012 - 55.9 percent; 2013 - 57.1 percent; 2014 - 56.6 percent; 2015 - 55.8 percent; 2016 - 56.0 percent (Autorengruppe Bildungsberichterstattung, 2017, p. 297; Hochschulrektorenkonferenz, 2017, p. 7)

In the first chapter, I examine the influence of the Bologna reform on educational outcomes of university graduates in Germany. The abolition of the traditional one-tier university system and the introduction of the two-tier university system with bachelor's and master's degrees is among the most substantial policy reforms in higher education in Germany in the last decades. With data from the German Student and Examination Statistics, which cover the universe of German university students between 1995 and 2015, I test whether the Bologna reform has had an effect on the study duration and grades of university graduates in Germany. Therefore, I exploit variations in the introduction of new bachelor's and master's degree programs across university departments over time. To account for selection into treatment, e.g., enrolling in a bachelor's program, I also use an instrumental variable approach introduced by Enzi and Siegler (2016). To the best of my knowledge, I am the first to examine the effect of the Bologna reform on study duration for graduates from all German public universities, as existing evidence concentrates on graduates from two selected universities (Hahm and Kluve, 2016; Lerche, 2016). I also contribute to the existing literature by including master's students in my analysis and by analyzing whether the effects are heterogeneous for students from different fields of study. I find that the introduction of the two-tier university system is associated with a reduction of the overall study duration as well as with a reduction of the standardized study duration of university graduates in Germany in most fields of study.

The second chapter focuses on the effects of the CHE university ranking on graduate students' university choice in Germany. The question of the university at which to enroll for a master's degree has become more and more important to students in recent years, since different policy reforms, for example the German excellence initiative, have actively promoted competition between public universities in Germany. Still, existing evidence predominantly stems from the UK and US (e.g., Griffith and Rask, 2007; Broecke, 2015; Gibbons et al., 2015; Meyer et al., 2017). The only study of the effect of university rankings on students' enrollment decisions in Germany focuses exclusively on medical students (Horstschräer, 2012). As far as I am aware, I am the first to study the effect of university rankings on university enrollment for students from all fields of

study. In the empirical analysis I exploit variations in subject-specific university ranking scores between 2010 and 2015 and use data from the German Student and Examination Statistics. The results show that an increase in the ranking indicator overall student satisfaction is associated with a significantly higher enrollment probability of master's students from almost all fields of study in the following years.

The third chapter, which is joint work with Markus Nagler, aims to investigate whether local labor market shocks affect human capital investments, e.g., enrollment in higher education and field of study choice. Our findings complement the existing literature on the impacts of nationwide macroeconomic downturns on the choice of field of study in the US (Blom et al., 2015; Liu et al., 2017) by examining whether local labor market shocks also matter. We exploit within-region-of-high-school-graduation changes in unemployment rates and also use data from the German Student and Examination Statistics for the empirical analysis. We find that increases in local unemployment are related to an increase in the share of students graduating in STEM subjects and business studies and a decrease in those studying law. The effects are substantially stronger at graduation than at initial enrollment.

Although the topics are closely related and make use of the same data set for the empirical analysis, all chapters are self-contained and can be read separately. The appendices are presented after the main text, followed by a joint bibliography at the end of this dissertation.

Chapter 1

From a One-Tier to a Two-Tier University System: Evidence from the Bologna Reform in Germany

1.1 Introduction

The Bologna reform is among the most important policy reforms of the German higher education system in the last decades. The abolition of the one-tier university system with its traditional magister and diploma degrees and the introduction of the two-tier university system with new bachelor's and master's degrees has induced a substantial restructuring of study programs in Germany. With this change in study structure, German policy makers not only aimed to improve internationalization and increase the mobility of students, but also sought to reduce the study duration of German university graduates before obtaining a first degree, as study lengths as well as labor market entry ages were comparatively high in Germany during that time (Wissenschaftsrat, 2000).

Whether a reduction of study duration was successfully accomplished with the introduction of the Bologna reform is the central research question in this paper. As far as I am aware, I am the first to examine the impact of the Bologna reform on the study duration of graduates throughout Germany. To my knowledge, the effects of the Bologna reform on time until graduation have only been examined by Hahm and Kluve (2016) for bachelor's graduates at the Humboldt University Berlin and by Lerche (2016) for the

University Göttingen. For my empirical analysis I use data from the Student and Examination Statistics, an administrative data set that covers all German university graduates from 1995 to 2015.

The size of the data set also allows me to analyze the effect of the Bologna reform on subgroups, for example graduates from different fields of study. In addition, I am the first not only to compare bachelor's degree graduates to old degree program graduates, but also to include students who graduated from second-cycle master's degree programs in some parts of my empirical analysis.

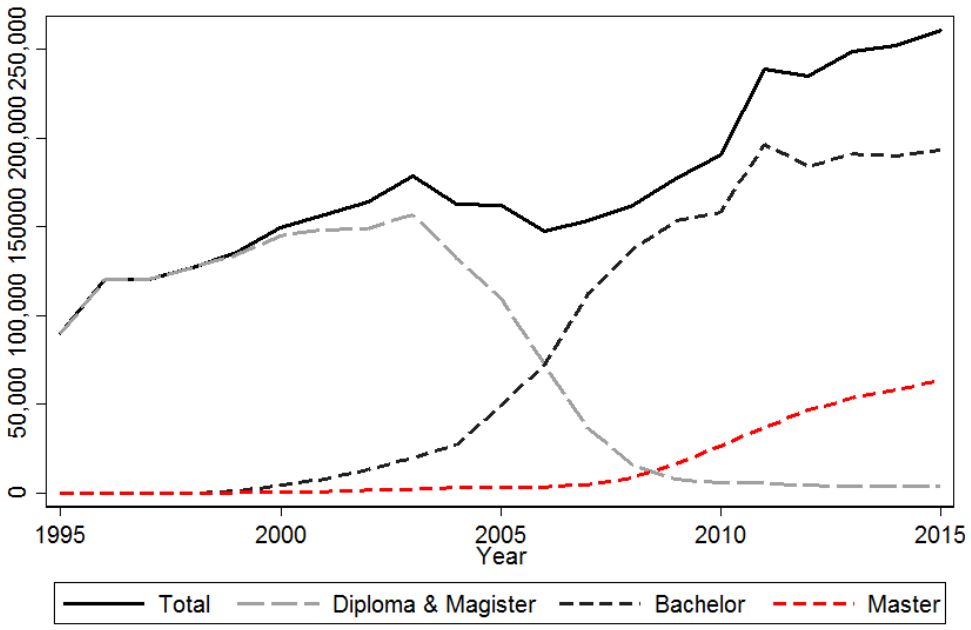
It should be noted that the empirical analysis focuses on the quantitative indicator of absolute and relative study duration. Whether and to what extent the study content and its quality were adapted or changed with the introduction of the new degree programs and whether the Bologna reform strengthened the employability of German university graduates are topics beyond the scope of this paper.

As in previous papers on the effects of the Bologna reform in Germany (e.g., Horstschräer and Sprietsma, 2015; Hahm and Kluve, 2016), in my empirical strategy I exploit the fact that due to its decentralized introduction in Germany, both the old and the new degree programs coexisted for several years. University departments in Germany could decide when to introduce bachelor's and master's degrees and end diploma and magister degrees during the period from 1999 to 2010. Figure 1.1 shows the number of first-year students by degree type in Germany between 1995 and 2015.

In addition, I use an instrumental variable approach, which was first implemented by Enzi and Siegler (2016). Taking the distance differential between a students' nearest university that offers a bachelor's program and the nearest university that offers a magister or diploma program as an instrumental variable, I account for any endogeneity caused by students who actively self-select into or avoid bachelor's degree programs.

My empirical findings reveal that the introduction of bachelor's and master's degrees reduced the study durations of university graduates in absolute as well as relative terms. For example, the likelihood of graduating within the standard study duration increases by 23 percentage points for students from bachelor's programs compared to students

Figure 1.1: *First-Year Students in Germany by Degree*



Notes: This figure is based on data from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen") and includes first-year students enrolled in the fields of study listed in Appendix A.1 and the public universities listed in Appendix A.2.

from diploma or magister programs. Master's degree students are 17 percentage points more likely to graduate within the standard study duration. The results are robust in various OLS specifications as well as in the IV regression analysis.

Sample split results show that the effects of the Bologna reform on study duration are highly heterogeneous. The introduction of the new degree programs caused a significant reduction in study duration for students from the field of linguistic and cultural sciences as well as for students from business, economics, and the social sciences, but in contrast increased the relative study duration for engineering graduates.

The remainder of the chapter is structured as follows: Section 1.2 gives a short overview of the institutional background of the Bologna reform in Germany. In Section 1.3 the related literature is reviewed. Section 1.4 provides details on the employed data and presents the respective descriptive statistics. Section 1.5 outlines the empirical approach and Section 1.6 presents the estimation results. Section 1.7 discusses possible channels and concludes.

1.2 Institutional Background

The Bologna Declaration was signed in 1999 by the European Ministers of Education and was intended to establish a common European higher education area. Its main goals included improvement of the international competitiveness of the higher education system in Europe, increased student mobility, and the greater employability of European university graduates.

Of greatest relevance to creating an area of higher education was the introduction of a homogenous two-tier university system (bachelor's and master's degrees) throughout Europe. The bachelor's degree is an undergraduate degree that is supposed to be more labor-market-oriented and consists of a minimum of three years of study. The master's degree is a graduate and more research-oriented degree that requires the successful completion of an undergraduate degree (Bologna Declaration, 1999).

The adoption of bachelor's and master's degrees varied across the countries of Europe. While, for example, the UK already had a two-tier university system before the reform and only minor changes were required, countries like Germany with a traditional one-tier university system had to substantially restructure their study programs. Before the Bologna reform, the common one-cycle degrees in Germany were the diploma and the magister. While the diploma degree was predominantly awarded in the fields of the natural sciences, engineering, and business, the magister degree was mostly awarded in the cultural, linguistic, and social sciences.

As the restructuring of existing study programs was necessary, the Bologna reform provided a good opportunity to adapt and improve the German higher education system. Besides the internationalization of programs, the primary focus was on lowering student drop-out rates and reducing study duration. According to the German Science Council ("Wissenschaftsrat"), one of the main reasons for the extensive study duration of 6.7 years of German university graduates in the 1990s was the relatively free study program design in the diploma and magister degrees (Wissenschaftsrat, 2000, p. 9).

Hence, besides a shorter standard study duration needed to obtain a first university degree, the new degree programs came with more structured and predetermined study

plans. The students' freedom to choose courses and the individual timing of examinations characteristic of the old degree programs were reduced tremendously in bachelor's and master's programs. In addition, grades are now awarded for almost all courses, and all grades from the first semester onwards count toward the final grade in the new programs.

With the introduction of bachelor's degrees, German policy makers had high hopes of reducing study duration and the age of university graduates entering the labor market. Whether the restructuring of study programs during the Bologna process really decreased the study duration of German university graduates is the main research question of this paper. In addition, I also examine whether the Bologna reform had an influence on the final grades of students.

1.3 Related Literature

The introduction of bachelor's and master's degrees under the Bologna reform had a great effect on the tertiary education system in countries that did not already have a two-tier university system in place. Among others this included Germany, Italy, and Portugal, which are the countries covered most intensively by the existing literature.

As a bachelor's degree can be earned more quickly than the diploma or magister degree, it was a common belief among politicians that the Bologna reform would increase university enrollment and reduce drop-out rates. However, as the expected returns of the new degree are unknown, the effects of the reform are not unambiguous in theory (Horstschräer and Sprietsma, 2015). Hence, one major topic discussed in the literature is whether the Bologna reform really increased university enrollment and reduced drop-out rates.

For Germany, Horstschräer and Sprietsma (2015), who also use data from the German Student and Examination Statistics, do not find a significant impact on enrollment or on drop-out rates for most subjects. Lerche (2016), who uses data from the University of Göttingen, does not find any conclusive results for drop-out rates in most fields of study, except that drop-out rates in the faculties of humanities are significantly lower for

bachelor's degree students than for old degree program students. Neugebauer (2015) shows that in Germany, the introduction of the bachelor's degree has no effect on the share of students from lower socioeconomic backgrounds attending higher education.

In contrast, the empirical results imply that the Bologna reform indeed has had an effect on enrollment and drop-out rates in Italy. Using survey data, Cappellari and Lucifora (2009) show that the introduction of the bachelor's degree significantly increased the probability of university enrollment, especially for well performing students with unfavorable parental backgrounds. Di Pietro (2012), who uses a more sophisticated empirical strategy, confirms this positive effect, although with a smaller magnitude. In Italy the positive effect on enrollment might be partially due to the fact that the empirical evidence indicates that the reform significantly increased the employment of graduates in almost all regions (Bosio and Leonardi, 2011). With respect to drop-out rates, Di Pietro and Cutillo (2008) show that the Bologna reform in Italy is also associated with positive changes in student behavior, which in turn led to a decline in drop-out rates.

Other studies using data from Germany and Portugal investigate student satisfaction and the perceived attractiveness of bachelor's programs among high school graduates. Mühlenweg (2010), who uses a repeated cross section survey of students in Germany, shows that students enrolled in bachelor's programs are slightly more satisfied with their studies than students enrolled in a traditional degree program. Enzi and Siegler (2016), using survey data, also find increased study satisfaction but no effects of the Bologna reform on students' mobility or internship participation. Cardoso et al. (2008) and Portela et al. (2009) show that academic programs that had already implemented the Bologna reform were in higher demand in Portugal during the time when both new and old degree programs coexisted.

As previously mentioned, there are two existing studies from Germany that examine the effects of the Bologna reform on study duration. Hahm and Kluve (2016), who use data from the Humboldt University in Berlin, find a significant decrease in the standardized study duration and a significant increase in the probability of graduating within the planned instructional time. In addition, they show that overall final grades are significantly worse for bachelor's graduates than for diploma and magister graduates. Lerche

(2016) also finds a reduced duration until graduation in absolute and relative terms for students from the University of Göttingen.

This paper contributes to the existing literature by assessing whether the findings of Hahm and Kluve (2016) and Lerche (2016) hold for universities throughout Germany. Access to data covering all German university graduates also allows me to account for potential endogeneity by using the instrumental variable approach introduced by Enzi and Siegler (2016).

I also include master's degree graduates in my analysis, and thus, as far as I am aware, I am the first to compare the educational outcomes of students who completed both degree cycles with the outcomes of students of the old degree programs. Additionally, I contribute to the existing literature by examining whether the Bologna reform had heterogeneous effects for graduates from different fields of study.

1.4 Data and Descriptive Statistics

In this section I describe the data and provide information on the study duration index used in the later empirical analysis. I then present some descriptive statistics.

1.4.1 German Student and Examination Statistics

For the empirical analysis I use data from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), which is based on administrative student data of all German universities. The data set is provided by the Research Data Centers of the Federal Statistical Office and the Statistical Offices of the Federal States ("Forschungsdatenzentrum des Bundes und der Statistischen Ämter") for the years 1995-2015 and contains a full student census for the winter terms and a census only of first-year students and graduates for the summer terms.

The data set includes information on basic student characteristics, such as sex, year and month of birth, and nationality, as well as various relevant information on studies and graduation, such as year and county of university entrance qualification ("Abitur/ Hochschulzugangsberechtigung"), year of first university enrollment, university of first

enrollment, current university, university major, type of degree, final overall grade, duration of studies, etc. While the type of degree (diploma, magister, bachelor's, or master's) is the variable determining the treatment status in my analysis, the final overall grade and duration of studies are outcome variables.

As the data include information on students and graduates from all German universities for the extensive period of 20 years, the large sample size is one main benefit of its use. In addition, as student registration offices are obliged by law to collect the respective data[1], data quality is presumably good and non-representativeness or item non-response, etc., are not a major concern (Marcus and Zambre, 2018). The only disadvantages of the data set are the limited set of individual control variables and the fact that the data set is in a repeated cross section format and individuals cannot be linked across different semesters due to data protection regulations. However, missing individual controls should not be a major concern for causal identification in my empirical analysis, as Neugebauer (2015) has shown that in Germany the Bologna reform did not have an effect on the share of students with a less educated parental background.

1.4.2 Standard Study Duration

The standard study duration ("Regelstudienzeit") of a given study program is an important piece of information needed to evaluate the duration of studies of a graduate in the later analysis. Unfortunately, in the data of the Student and Examination Statistics only the semesters actually studied are included, not the standard study duration for the specific study program.

The standard study duration varies across universities and fields of study and is defined by the examination and study regulations ("Prüfungs- und Studienordnung") of the respective university. However, the Rectors' Conference of German Universities ("Hochschulrektorenkonferenz") has provided non-binding recommendations for the standard study duration for magister and diploma degrees for various study subjects. Based on this information I define the standard study duration for magister degrees as

[1] Higher Education Statistics Act ("Hochschulstatistikgesetz, HStatG") November 2nd, 1990

9 semesters and for diploma degrees between 8 and 10 semesters depending on the field of study.[2] As the vast majority of bachelor's degrees have a standard study duration of 6 semesters and master's degrees have 4 semesters of standard study duration, I define 6 and 4 semesters as the standard study durations for the new degree programs (Hochschulrektorenkonferenz, 2015, p. 16).

With the conservative definition of standard study duration for magister and diploma degrees[3], this approach most likely underestimates the treatment effect of the Bologna reform on the relative study duration. However, to check the validity and robustness of my results, I selected the exact standard study durations for all study programs at public universities in Bavaria. For magister and diploma degrees I collected the examination and study regulations from the official journal of the Bavarian State Ministry for Education and Cultural Affairs ("Amtsblatt des Bayerischen Staatsministeriums für Bildung und Kultus, Wissenschaft und Kunst"), while for bachelor's and master's degrees I obtained the information from the database of the Rectors' Conference of German Universities.

Following Hahm and Kluve (2016), I also use a study duration index to measure relative study duration:

$$\textit{Study duration index}_{isd} = \frac{SRS_{isd}}{SSD_{sd}}$$

where SRS_{isd} are the subject-related semesters individual i studied in subject s to obtain degree d and SSD_{sd} is the standard study duration measured in semesters for subject s and degree d. The study duration index allows the direct comparison of the relative study durations of bachelor's, master's, diploma, and magister degree students in the following analysis.

[2] For detailed information on the assumed standard study duration, please refer to Appendix A.1.

[3] I take the maximum standard study duration proposed by a framework regulation and apply this standard study duration to all subjects in the same subject area if there is no framework regulation available for a certain subject.

1.4.3 Descriptive Statistics

In my empirical analysis I use bachelor's, master's, diploma, and magister graduates from all public universities in Germany listed in Appendix A.2 for the years 1995 to 2015. Graduates in human medicine & health science, veterinary medicine, and law as well as teaching degree graduates are not considered in the empirical analysis because the vast majority of degrees awarded in these fields remain state exams or are a combination of new degree programs and state exams.[4] I also only include full-time students graduating from on-campus study programs.

In addition, only students who successfully graduated remain in the data set. Hence, all later results are "conditional on successful graduation" by the respective student. As previous papers have shown that the Bologna reform did not have an effect on dropout rates for the vast majority of subjects (Horstschräer and Sprietsma, 2015; Lerche, 2016), the exclusive inclusion in the data of students who successfully graduated should not be a problem for the empirical analysis.

Table 1.1 displays summary statistics of the variables used in the empirical analysis. There are relatively more female graduates in the new degree programs, and the shares of graduates in the different fields are not constant across degree types. While the share of students doing a degree in the linguistic and cultural sciences is higher for bachelor's students than for old degree program students, the opposite holds true for graduates from the field of engineering. Old degree program students in total spend around 14, bachelor's degree students around 8, and master's students around 12 semesters at university. It is important to be aware that the number of total semesters studied includes all semesters studied at a German university before graduation, e.g., for master's graduates it also includes all semesters studied in the undergraduate degree. In addition, it also includes semesters studied in other fields/degrees, for example study semesters where students dropped out before graduation, as well as vacations or practical semesters. In contrast to that, the subject-related semesters studied only include

[4] State exams ("Staatsexamen") are centralized final examinations organized by the federal states of Germany.

semesters studied in the study program of graduation. The study index, which is calculated as described in the previous sub-section, is 1.39 for diploma and magister students and 1.20 and 1.28 for bachelor's and master's students. The probability of graduating within the standard study duration is also lowest for old degree program students and highest for bachelor's students. The scale of final grades ranges from 100 (very good) to 400 (sufficient), and while bachelor's students on average have worse final grades than old degree program students, master's students have better grades than magister and diploma degree students.

Figure 1.2 presents the study index by degree and field of study. It shows that except for the field of engineering, magister and diploma students also studied relatively longer than bachelor's students when taking different standard study durations into account. For example, in the field of linguistic and cultural sciences, the average study index for diploma and magister students is 1.46, compared to 1.21 for bachelor's students.[5]

Figure 1.3 shows the share of students by degree and field of study that graduates within the standard study duration. The difference between old degree program and bachelor's degree program graduates is smallest in the field of engineering, where 15 percent of diploma students graduate within the standard instructional time versus 23 percent of bachelor's students. For all other fields of study the share of bachelor's students graduating within the standard study duration is significantly higher and ranges between 38 and 49 percent.

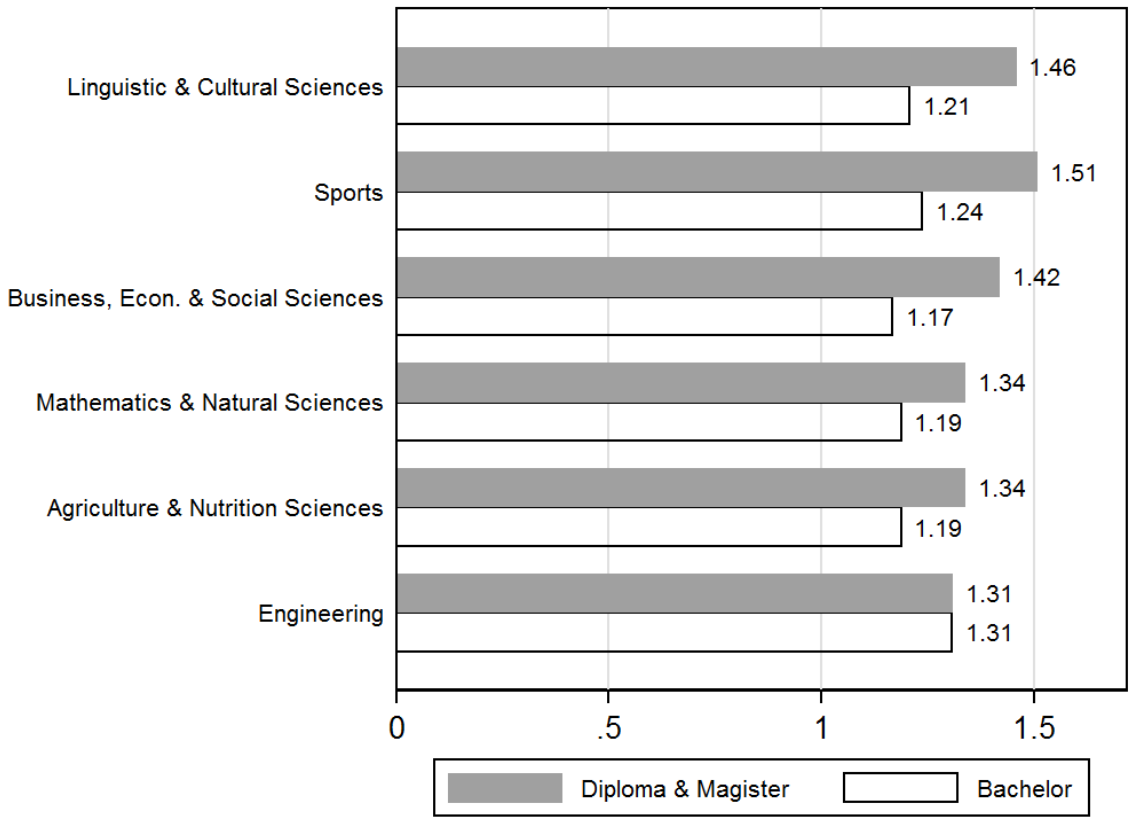
[5] With a standard study duration of 9 semesters for magister students in the field of linguistic and cultural sciences, this translates into an average of 13.14 semesters until graduation for old degree program students. Bachelor's students in the field of linguistic and cultural sciences on average graduate after 7.26 semesters.

Table 1.1: *Summary Statistics*

	Diploma & Magister	Bachelor's	Master's
Female	0.45	0.52	0.48
Year of Birth	1976.60	1987.27	1985.90
	(6.30)	(3.80)	(3.38)
Year of High School Graduation	1996.47	2007.01	2005.74
	(6.03)	(3.45)	(3.14)
Enrollment Age	21.01	20.55	20.90
	(2.34)	(2.08)	(2.39)
Linguistic & Cultural Sciences	0.15	0.18	0.12
Sports	0.01	0.01	0.01
Business, Economics & Social Sciences	0.39	0.38	0.32
Mathematics & Natural Sciences	0.24	0.24	0.27
Agriculture, Forest & Nutrition Sciences	0.02	0.04	0.06
Engineering	0.18	0.15	0.22
Age at Graduation	28.16	24.79	27.06
	(3.39)	(2.87)	(2.71)
Total Semesters Studied	14.04	8.27	11.96
	(4.10)	(2.94)	(3.35)
Subject-Related Semesters Studied	12.72	7.22	5.12
	(3.44)	(1.75)	(1.42)
Study Index	1.39	1.20	1.28
	(0.38)	(0.29)	(0.36)
Graduation Within Std. Study Duration	0.12	0.43	0.35
	(0.33)	(0.50)	(0.48)
Final Grade	185.13	210.01	164.13
	(71.96)	(62.16)	(60.70)
Observations	888,384	489,137	165,357

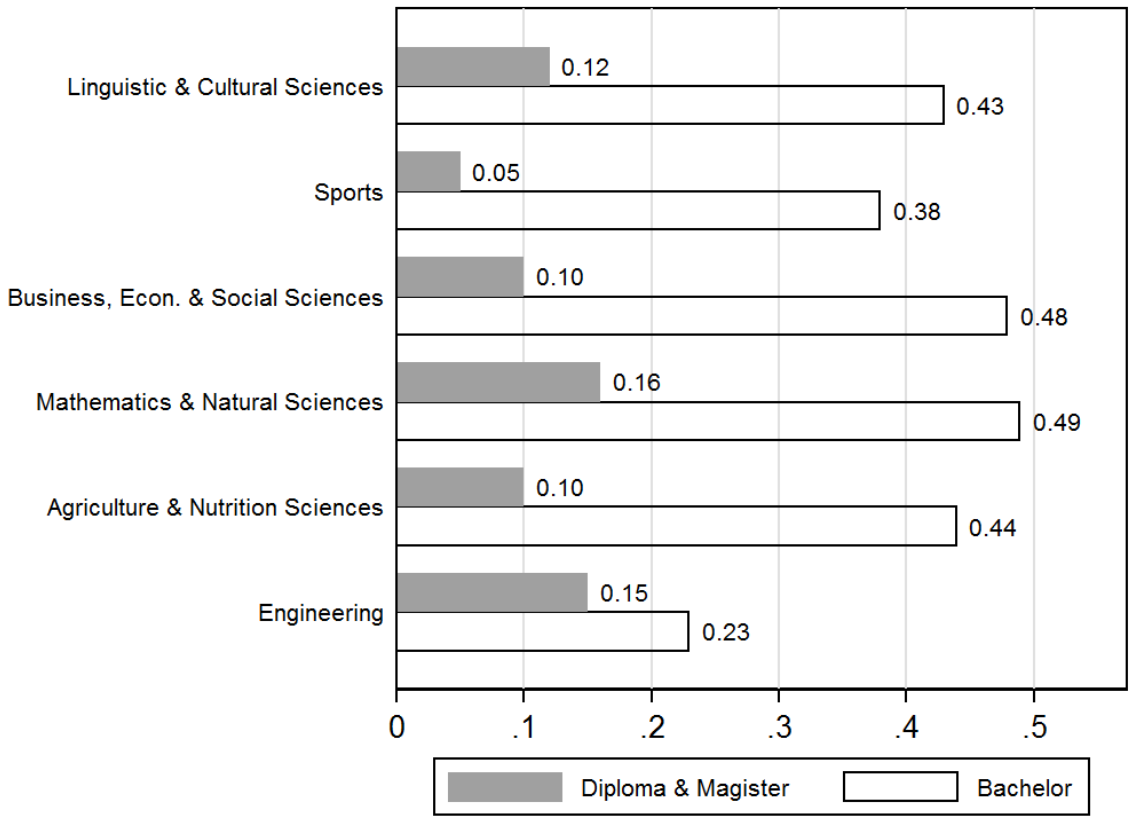
Notes: Summary statistics (means, standard deviation in parentheses) of the main variables. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), and the data on the standard study duration for the calculation of study index and graduation within the standard study duration from the Rectors' Conference of German Universities ("Hochschulrektorenkonferenz").

Figure 1.2: *Study Index by Degree and Field of Study*



Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), and the data on the standard study duration for the calculation of study index from the Rectors' Conference of German Universities ("Hochschulrektorenkonferenz").

Figure 1.3: *Share of Students Graduating Within Standard Study Duration by Degree and Field of Study*



Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), and the data on the standard study duration for the calculation of graduation within standard study duration from the Rectors' Conference of German Universities ("Hochschulrektorenkonferenz").

1.5 Empirical Strategy

In this section I present the empirical methodology, first the baseline OLS estimation equation and then the instrumental variable approach, which is taken from Enzi and Siegler (2016).

1.5.1 Ordinary Least Squares

As have previous papers on the effects of the Bologna reform in Germany, I exploit the fact that due to the decentralized introduction in Germany, bachelor's and master's programs coexisted with diploma and magister programs for several years. Hence, my baseline OLS estimation equation reads as follows:

$$y_i = \alpha + \beta degree_i + \gamma X_i + \delta_u + \theta_s + \mu_t + u_{ius}$$

y_i is the outcome of interest of graduate i. The different outcome variables in my empirical analysis are total semesters studied, subject-specific semesters studied, study index, probability of graduating within the standard study duration, and final overall grade. $degree_i$ indicates the degree type (diploma/magister, bachelor's, or master's) of graduate i, and β is the degree effect, which is the effect of main interest in my analysis. X_i are individual controls including sex, nationality, enrollment-age, state and type of university entrance qualification, and whether the student is enrolled in a double degree program. δ_u are university fixed effects, θ_s field of study fixed effects, and μ_t are year fixed effects.[6] The standard errors u_{ius} are clustered at the university-field of study level.

In additional specifications, I include university-field of study fixed effects and control for other educational reforms that have taken place by including state-year fixed effects.[7] I also run specifications with standard errors clustered on the university level only.

[6] Year of high school graduation is used as the year fixed effect, as year of high school graduation is, at least for the most part, exogenous.

[7] Educational reforms between 1995 and 2015 include reductions in the years of schooling in high school from 9 to 8 years and the introduction of centralized high school examination exams in various German states.

1.5.2 Instrumental Variable Approach

While I exploit the fact that old and new degree programs coexisted for several years in Germany in the OLS regression analysis, this coexistence allowed students to self-select into treatment. The availability of both old and new programs gave students, at least to some degree, the freedom to choose whether to enroll in a bachelor's or a diploma/magister program during that time.

To account for this potential endogeneity, I use the instrumental variable approach introduced by Enzi and Siegler (2016), in which the enrollment decision is instrumentalized by the distance differential between the hometown of a student and the nearest university offering a bachelor's degree and the nearest university offering a diploma or magister degree for the same subject.

Figure 1.4, which is based on the data used in the empirical analysis, shows the relevance of this instrumental variable, as German students prefer to choose a university close to their home town. Around 50 percent of students study at a university that is within 60 kilometers of the county where they received their university entrance qualification. This is in line with results presented by Spiess and Wrohlich (2010), who find that university attendance is negatively correlated with the distance to the university from a student's home.

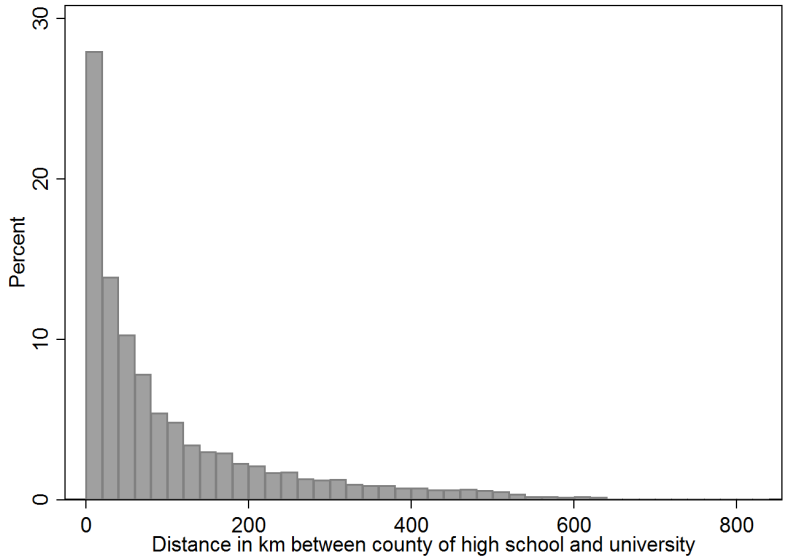
In addition, the instrumental variable is presumably exogenous, as the literature shows that the majority of students in Germany first choose their study subject and then their study location (Hachmeister et al., 2007, p. 58).

Hence, analogous to Enzi and Siegler (2016), I compute the instrumental variable as follows:

$$distanceIV_{cst} = distanceMagister/Diploma_{cst} - distanceBachelor_{cst}$$

$distanceMagister/Diploma_{cst}$ is the minimal distance from county c to a university that offers a magister or diploma degree in subject s in year t, which is the year of the first

Figure 1.4: *Distance Between County of University Entrance Qualification and Attended University*



Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"). Distance between counties (address of county administration) and universities based on own calculations.

semester of the student.[8] Accordingly, $distanceBachelor_{cst}$ is the minimal distance from county c to a university that offers a bachelor's degree in subject s in year t. $distanceIV_{cst}$ is the distance differential of the minimal distances. Thus, the first stage reads:

$$bachelor_{icst} = \alpha + \beta distanceIV_{cst} + \gamma X_i + \delta_u + \theta_s + \mu_t + u_{icus}$$

$bachelor_{icst}$ takes the value 1 if the student i from county c is enrolled in a bachelor's program in subject s and 0 if he/she is enrolled in a diploma or magister degree. As in the OLS regression model, X_i are individual controls, δ_u are university fixed effects, θ_s are field of study fixed effects, and μ_t are year of high school graduation fixed effects.

Unfortunately, master's degree students cannot be considered in this instrumental variable approach.

[8] The distance differential is computed with respect to the county where a student received his/her university entrance qualification, as the data do not include the residential address of the student at the time of high school graduation.
Due to the repeated cross section structure of the data, the year of first semester is not directly observed but needs to be computed by adding up all subject-related semesters and vocational semesters studied and then subtracting years studied from the year of university graduation.

1.6 Results

In this section I present my estimation results on the impact of the Bologna reform on educational outcomes of university graduates in Germany. First, I present OLS estimation results, and second, estimation results from the instrumental variable approach. Third, I analyze the heterogeneity of results with respect to different fields of study.

1.6.1 OLS Results

Table 1.2 reports the baseline OLS regression results for the dependent variables of total semesters studied, subject-related semesters studied, study index, graduation within standard study duration, and final grade.

The results suggest that the Bologna reform has significantly reduced absolute and relative study durations of German university graduates, especially for students in the first study cycle (e.g., bachelor's students). The strong negative effect of graduating from a bachelor's program on total semesters and subject-related semesters is at least partly caused by the fact that bachelor's programs have a period of standard study that is 2 to 4 semesters shorter than the old degree programs. However, the OLS coefficient for the study index, which takes the different standard study durations into account, is also negative and highly significant. At the same time, the probability of graduating within the standard study duration is 23 percentage points higher for bachelor's programs.

Students who completed a master's degree in addition to their bachelor's degree studied on average only around half a semester longer than students graduating from the old degree programs. While the master's degree has no significant effect on the study index, the graduation within the standard study duration is still around 17 percentage points higher for the master's than for old degree program students.

With respect to final grades, the results reveal that grades are significantly worse by 0.38 for bachelor's graduates and significantly better by -0.14 for master's students than for diploma and magister students.[9]

[9] The scale 100 to 400 has been converted to the more common scale of 1.0 to 4.0.

Table 1.2: *Bologna Reform and Educational Outcomes*

Dependent:	Total Semester	Subject-Related Semester	Study Index	Graduation Within Std.	Final Grade
	(1)	(2)	(3)	(4)	(5)
Bachelor's	-2.936***	-4.458***	-0.044***	0.228***	37.760***
	(0.068)	(0.066)	(0.011)	(0.013)	(1.908)
Master's	0.504***	-6.782***	0.009	0.168***	-14.330***
	(0.085)	(0.081)	(0.010)	(0.012)	(1.69)
Female	-0.324***	-0.274***	-0.044***	0.033***	-6.849***
	(0.026)	(0.021)	(0.002)	(0.003)	(1.042)
Enrollment Age	-0.231***	-0.031***	-0.003***	0.000	1.031***
	(0.006)	(0.004)	(0.000)	(0.000)	(0.124)
Double Degree	0.343***	0.087*	0.032***	-0.092***	-3.710**
	(0.048)	(0.048)	(0.008)	(0.013)	(1.451)
Nationality FE	YES	YES	YES	YES	YES
State of HZB[1] FE	YES	YES	YES	YES	YES
Year of HZB[1] FE	YES	YES	YES	YES	YES
Field of Study FE	YES	YES	YES	YES	YES
University FE	YES	YES	YES	YES	YES
Observations	1,542,878	1,542,878	1,542,878	1,542,878	1,513,378
Adjusted R^2	0.478	0.601	0.175	0.155	0.142

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on the standard study duration for the calculation of study index and graduation within standard study duration from the Rectors' Conference of German Universities ("Hochschulrektorenkonferenz"). Robust standard errors, clustered on the university-field of study level, are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

[1]HZB ("Abitur/Hochschulzugangsberechtigung") is the German university entrance qualification.

Table 1.3 displays the regression results for various robustness checks for specifications with study index as dependent variable. The first column reports the results for a specification where standard errors are clustered on the university level only. The second column includes state-year of high school examination fixed effects to control for educational reforms on the state level. The third column includes university-field of study and the fourth column university-subject area fixed effects. The size and significance of the effect of the Bologna reform on study index is robust across the different specifications. Appendix A.3 includes tables with the respective robustness checks for specifications with graduation within standard study duration and final grade.

Table 1.4 shows OLS regression results for study index and graduation within the standard study duration for graduates from Bavarian universities only. While in the first and third columns the standard study duration is defined as described in Appendix A.1, the results in the second and fourth columns were obtained using the standard study duration stipulated by the examination and study regulations as provided in the official journal of the Bavarian State Ministry for Education and Cultural Affairs for magister and diploma studies, and the database of the Rectors' Conference of German Universities for bachelor's and master's degrees.

The estimation results for the study index in the first and second columns as well as for graduation within the standard study duration in the third and fourth columns are very similar, and they are also all highly significant for bachelor's degree students. Hence, the standard study duration rule as described in Appendix A.1 seems a good approximation to the real standard study duration.

Table 1.3: *Bologna Reform and Study Index: Robustness*

Dependent:	Study Index			
	(1)	(2)	(3)	(4)
Bachelor's	-0.044***	-0.045***	-0.046***	-0.045***
	(0.013)	(0.011)	(0.011)	(0.009)
Master's	0.009	0.006	0.007	0.010
	(0.012)	(0.010)	(0.010)	(0.008)
Female	-0.044***	-0.044***	-0.043***	-0.031***
	(0.003)	(0.002)	(0.002)	(0.001)
Student Controls[1]	YES	YES	YES	YES
State of HZB[2] FE	YES	—	YES	YES
Year of HZB[2] FE	YES	—	YES	YES
State-Year of HZB[2] FE	—	YES	—	—
University FE	YES	YES	—	—
Field of Study FE	YES	YES	—	—
University-Field of Study FE	—	—	YES	—
University-Subject Area FE	—	—	—	YES
Observations	1,542,878	1,542,878	1,542,878	1,542,878
Adjusted R^2	0.175	0.184	0.185	0.216

Notes: The first column is the baseline regression with standard errors clustered on the university level only. The second column includes state-year fixed effects to control for educational reforms on the state level; standard errors are clustered at the university-field of study level. The third column includes university-field of study fixed effects; standard errors are clustered on the university-field of study level. The fourth column includes university-subject area fixed effects, and standard errors are clustered on the university-subject area level. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on the standard study duration for the calculation of study index from the Rectors' Conference of German Universities ("Hochschulrektorenkonferenz"). Significance levels: *** 1%, ** 5%, * 10%.

[1]Student controls include enrollment age, double degree, and nationality fixed effects.

[2]HZB ("Abitur/Hochschulzugangsberechtigung") is the German university entrance qualification.

Table 1.4: *Bologna Reform and Study Index / Graduation within Standard Study Duration: Bavaria*

Dependent:	Study Index		Graduation Within Std.	
	(1) Framework Regulations	(2) Examination Regulations	(3) Framework Regulations	(4) Examination Regulations
Bachelor's	-0.062***	-0.066***	0.278***	0.304***
	(0.019)	(0.021)	(0.030)	(0.028)
Master's	-0.002	0.016	0.192***	0.188***
	(0.016)	(0.022)	(0.025)	(0.026)
Female	-0.031***	-0.026***	0.046***	0.038***
	(0.004)	(0.006)	(0.007)	(0.006)
Enrollment Age	0.000	0.001	-0.001	-0.001*
	(0.001)	(0.001)	(0.001)	(0.001)
Double Degree	0.060***	0.058***	-0.171***	-0.170***
	(0.021)	(0.021)	(0.030)	(0.033)
Nationality FE	YES	YES	YES	YES
State of HZB[1] FE	YES	YES	YES	YES
Year of HZB[1] FE	YES	YES	YES	YES
Field of Study FE	YES	YES	YES	YES
University FE	YES	YES	YES	YES
Observations	276,096	273,257	276,096	273,257
Adjusted R^2	0.152	0.143	0.160	0.180

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"). In Columns 1 and 3 the standard study duration is defined as described in Appendix A.1, and the respective data are taken from the Rectors' Conference of German Universities ("Hochschulrektorenkonferenz"). In Columns 2 and 4 the standard study duration is defined by the examination and study regulations stipulated in the official journal of the Bavarian State Ministry for Education and Cultural Affairs ("Amtsblatt des Bayerischen Staatsministeriums für Bildung und Kultus, Wissenschaft und Kunst") for magister and diploma studies, and is from the database of the Rectors' Conference of German Universities ("Hochschulrektorenkonferenz") for bachelor's and master's degrees. Robust standard errors clustered on the university-field of study level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

[1]HZB ("Abitur/Hochschulzugangsberechtigung") is the German university entrance qualification.

1.6.2 IV Results

Table 1.5 displays the first-stage regression results. The instrumental variable, namely the distance differential of the home county of a student and a university offering a bachelor's degree versus a university offering an old degree program, is correlated with the outcome variable and is highly significant.

Only around 650,000 students are included in the IV approach for two reasons: First, as previously mentioned, as the IV approach is only suitable for comparing bachelor's to old degree program students, master's students cannot be taken into consideration. Second, the IV approach is only possible for those students who started their studies in a year when old and new degree programs were available in the respective study subject of the student. Otherwise the instrumental variable, namely the distance differential between the hometown of a student and the nearest universities offering a bachelor's degree or an old degree program, cannot be calculated.

Table 1.6 shows second-stage IV as well as OLS regression results for the outcome variable study index, graduation within standard study duration, and final grade. Among the measures of relative study durations, IV estimates are slightly larger in size than the OLS regression results. The IV study index estimate of -0.139 and the IV estimate for the probability of graduating within standard study duration of 34 percentage points indicate a substantial reduction of study duration due to the Bologna reform.

Hence, I also find strong positive effects of the Bologna reform on relative study duration and negative effects on the final grades of bachelor's graduates when controlling for possible self-selection of students into old or new degree programs.

Table 1.5: *Bologna Reform: First Stage IV*

Dependent:	Bachelor's Degree
Distance IV	0.086***
	(0.003)
Female	-0.002
	(0.004)
Enrollment Age	0.015***
	(0.001)
Double Degree	0.092***
	(0.016)
Nationality FE	YES
State of HZB[1] FE	YES
Year of HZB[1] FE	YES
Field of Study FE	YES
University FE	YES
Observations	651,145
F-Statisic	756.36

Notes: Dependent variable indicates studying in a bachelor's degree program (=1) vs. studying in a diploma/magister degree program (=0). Distance IV measured in 100 kilometers. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"). Robust standard errors clustered on the university-field of study level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

[1]HZB ("Abitur/Hochschulzugangsberechtigung") is the German university entrance qualification.

Table 1.6: *Bologna Reform: Second Stage IV vs. OLS Results*

Dependent:	Study Index		Graduation Within Std.		Final Grade	
	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
Bachelor's	-0.055***	-0.139***	0.253***	0.341***	39.14***	38.36***
	(0.010)	(0.015)	(0.013)	(0.021)	(1.940)	(3.405)
Female	-0.056***	-0.058***	0.058***	0.059***	-6.362***	-6.375***
	(0.003)	(0.003)	(0.004)	(0.004)	(1.046)	(1.026)
Enrollment Age	0.003***	0.004***	-0.004***	-0.006***	1.627***	1.644***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.126)	(0.157)
Double Degree	0.050***	0.059***	-0.141***	-0.150***	-3.561**	-3.481**
	(0.009)	(0.010)	(0.015)	(0.016)	(1.456)	(1.496)
Nationality FE	YES	YES	YES	YES	YES	YES
State of HZB[1] FE	YES	YES	YES	YES	YES	YES
Year of HZB[1] FE	YES	YES	YES	YES	YES	YES
Field of Study FE	YES	YES	YES	YES	YES	YES
University FE	YES	YES	YES	YES	YES	YES
Observations	651,145	651,145	651,145	651,145	644,514	644,514
Adjusted R^2	0.118	0.110	0.148	0.144	0.140	0.140

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on the standard study duration for the calculation of study index and graduation within standard study duration from the Rectors' Conference of German Universities ("Hochschulrektorenkonferenz"). Robust standard errors clustered on the university-field of study level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.
[1]HZB ("Abitur/Hochschulzugangsberechtigung") is the German university entrance qualification.

1.6.3 Heterogeneity

Table 1.7 reports OLS regression results for study indexes for the different fields of study. With -0.14, the effect of the introduction of the bachelor's degree on the study index is largest for graduates from the field of linguistic and cultural sciences. In addition, the Bologna reform reduced the relative study duration for bachelor's graduates from the field of sports as well as for students from business, economics, and social sciences by around -0.11 and -0.10. In contrast, bachelor's graduates from the field of engineering have a study index 0.14 higher than that of graduates from the old degree program. Hence, for bachelor's engineering students the Bologna reform had a negative effect on relative study duration, as it increased the study index. No effect can be detected for bachelor's students from the fields of mathematics and natural sciences or for agriculture, forest, and nutrition sciences.

Table 1.8 displays the sample split regression results for graduation within standard study duration. The Bologna reform significantly increased the probability of graduating within the standard study duration for bachelor's and master's students of all fields except for bachelor's graduates in the field of engineering. The estimates range from 11 percentage points for sports master's program graduates to 33 percentage points for bachelor's program graduates from agriculture, forest and nutrition sciences.

Table 1.9 shows the sample split regression results for the final grade as the dependent variable. Final grades are significantly worse for bachelor's graduates than for old degree program graduates for all fields of study. However, the magnitude of the effect varies across fields. While bachelor's students from the field of mathematics and natural sciences have grades that are worse by 0.64, the grades of bachelor's students from the field of linguistic and cultural sciences are only worse by 0.19.[10] Master's students, on the other hand, have significantly better grades than diploma/magister students, but also for master's students the effect varies from a slight difference of -0.03 for graduates from the field of mathematics and natural sciences to -0.17 for graduates from linguistic and cultural sciences and -0.19 for engineering graduates.

[10] The scale 100 to 400 has been converted to the more common scale of 1.0 to 4.0.

Table 1.7: *Bologna Reform and Study Index: Field of Study*

Dependent:	Study Index					
	(1) Linguistic & Cultural Sciences	(2) Sports	(3) Business, Economics & Social Sciences	(4) Mathematics & Natural Sciences	(5) Agriculture, Forest & Nutrition Sciences	(6) Engineering
Bachelor's	-0.141***	-0.106***	-0.103***	0.007	-0.020	0.140***
	(0.021)	(0.035)	(0.013)	(0.019)	(0.036)	(0.019)
Master's	-0.005	-0.010	-0.031**	0.058***	0.061**	0.042
	(0.019)	(0.035)	(0.015)	(0.016)	(0.026)	(0.028)
Female	-0.047***	-0.093***	-0.040***	-0.046***	-0.007	-0.037***
	(0.009)	(0.008)	(0.004)	(0.004)	(0.007)	(0.008)
Enrollment Age	-0.003***	-0.004*	-0.004***	0.000	-0.003***	-0.003**
	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)
Double Degree	-0.015	0.012	0.009	0.021*	0.049	0.042***
	(0.009)	(0.016)	(0.008)	(0.012)	(0.029)	(0.011)
State of HZB[1] FE	YES	YES	YES	YES	YES	YES
Year of HZB[1] FE	YES	YES	YES	YES	YES	YES
Nationality FE	YES	YES	YES	YES	YES	YES
University FE	YES	YES	YES	YES	YES	YES
Observations	235,874	19,757	590,262	372,801	48,136	276,048
Adjusted R^2	0.225	0.242	0.210	0.175	0.152	0.162

Notes: This table reports the effects of the Bologna reform on study index for sample splits by field of study as indicated by the column header. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on the standard study duration for the calculation of study index and graduation within the standard study duration from the Rectors' Conference of German Universities ("Hochschulrektorenkonferenz"). Robust standard errors clustered on the university-field of study level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

[1]HZB ("Abitur/Hochschulzugangsberechtigung") is the German university entrance qualification.

Table 1.8: *Bologna Reform and Graduation within Standard Study Duration: Field of Study*

Dependent:	Graduation Within Std.					
	(1) Linguistic & Cultural Sciences	(2) Sports	(3) Business, Economics & Social Sciences	(4) Mathematics & Natural Sciences	(5) Agriculture, Forest & Nutrition Sciences	(6) Engineering
Bachelor's	0.264***	0.224***	0.289***	0.238***	0.325***	0.020
	(0.022)	(0.043)	(0.018)	(0.021)	(0.054)	(0.020)
Master's	0.149***	0.110***	0.204***	0.128***	0.185***	0.156***
	(0.021)	(0.038)	(0.019)	(0.016)	(0.033)	(0.037)
Female	0.026***	0.066***	0.030***	0.043***	-0.008	0.023**
	(0.005)	(0.009)	(0.004)	(0.005)	(0.011)	(0.009)
Enrollment Age	-0.001**	0.001	0.002**	-0.005***	0.000	-0.000
	(0.000)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
Double Degree	-0.044***	-0.079***	-0.052***	-0.109***	-0.196***	-0.081***
	(0.011)	(0.025)	(0.014)	(0.022)	(0.064)	(0.020)
State of HZB[1] FE	YES	YES	YES	YES	YES	YES
Year of HZB[1] FE	YES	YES	YES	YES	YES	YES
Nationality FE	YES	YES	YES	YES	YES	YES
University FE	YES	YES	YES	YES	YES	YES
Observations	235,874	19,757	590,262	372,801	48,136	276,048
Adjusted R^2	0.178	0.238	0.209	0.170	0.169	0.081

Notes: This table reports the effects of the Bologna reform on graduation within the standard study duration for sample splits by field of study as indicated by the column header. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on the standard study duration for the calculation of study index and graduation within the standard study duration from the Rectors' Conference of German Universities ("Hochschulrektorenkonferenz"). Robust standard errors clustered on the university-field of study level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

[1]HZB ("Abitur/Hochschulzugangsberechtigung") is the German university entrance qualification.

Table 1.9: *Bologna Reform and Final Grade: Field of Study*

Dependent:	Final Grade					
	(1) Linguistic & Cultural Sciences	(2) Sports	(3) Business, Economics & Social Sciences	(4) Mathematics & Natural Sciences	(5) Agriculture, Forest & Nutrition Sciences	(6) Engineering
Bachelor's	18.99***	17.89***	26.04***	64.38***	38.12***	51.97***
	(2.343)	(4.987)	(2.869)	(1.790)	(9.138)	(3.748)
Master's	-17.32***	-17.34***	-15.24***	-2.794**	-7.307	-18.70***
	(1.990)	(4.884)	(3.216)	(1.348)	(12.60)	(4.228)
Female	8.318***	-8.556***	-17.53***	1.060	-3.856*	-0.361
	(0.608)	(0.901)	(1.064)	(0.801)	(1.910)	(1.265)
Enrollment Age	1.291***	1.450***	0.231*	2.830***	0.755**	1.745***
	(0.106)	(0.330)	(0.124)	(0.139)	(0.284)	(0.309)
Double Degree	-9.275***	-6.927**	-8.776***	-6.122***	2.135	2.384
	(1.341)	(2.579)	(1.516)	(1.420)	(4.441)	(2.196)
State of HZB[1] FE	YES	YES	YES	YES	YES	YES
Year of HZB[1] FE	YES	YES	YES	YES	YES	YES
Nationality FE	YES	YES	YES	YES	YES	YES
University FE	YES	YES	YES	YES	YES	YES
Observations	229,156	19,084	579,620	363,819	47,177	274,522
Adjusted R^2	0.075	0.145	0.124	0.195	0.149	0.173

Notes: This table reports the effects of the Bologna reform on final grade for sample splits by field of study as indicated by the column header. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on the standard study duration for the calculation of study index and graduation within standard study duration from the Rectors' Conference of German Universities ("Hochschulrektorenkonferenz"). Robust standard errors clustered on the university-field of study level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

[1]HZB ("Abitur/Hochschulzugangsberechtigung") is the German university entrance qualification.

1.7 Conclusion

Using data from the German Student and Examination Statistics, this paper shows that the Bologna reform has had significant effects on the educational outcomes of university students in Germany. One of the primary goals of policy makers in Germany, namely the reduction of the study duration of German university graduates, has been successfully accomplished with the Bologna reform. The estimation results of this paper reveal that the introduction of the new degree programs is associated with a reduction in relative study duration and an increased likelihood of graduating within the standard study duration for students from almost all fields of study.

Presumably, one reason why the Bologna reform reduced the relative study duration of German university graduates is the modular structure of the new study programs. Whereas under the old degree programs students were widely able to choose their courses and seminars as well as the timing of courses and examinations themselves, the new degree programs with modules and credit points (ECTS) provide a more structured study design (Wissenschaftsrat, 2000). The examination and study regulations of bachelor's and master's programs usually provide students with recommended study plans telling students exactly which modules to choose in which semester. The significant increase in the number of students graduating within the standard study duration indicates that many students adhere to the proposed study plans or, if they do not do so, the module structure enables them to adapt their studies to their personal needs within the standard study duration.

The heterogeneous results for the effects of the Bologna reform on the relative study duration in different fields of study can be explained by the different program structures in old degree programs. While magister study programs, which were predominately awarded in the cultural and linguistic sciences, were especially flexible and gave students a very high degree of freedom, diploma programs in the field of mathematics, natural sciences, and especially engineering already had by comparison a relatively structured study design.

Another possible explanation for the heterogeneous results regarding study duration

might be variations in the adoption of the study content in the new degree programs. Anecdotal evidence suggests that in some cases the study content of an 8-semester diploma degree was transferred over to the new 6-semester bachelor's degree without a noticeable reduction in the quantity and quality of the study content. This might be true for many bachelor's degrees in the field of engineering, where the German diploma was highly appreciated and respected worldwide.

The empirical analysis also reveals that bachelor's graduates have worse and master's degree graduates better grades than diploma and magister graduates. However, the substantial negative effect of the Bologna reform on the grades of bachelor's graduates should probably not be seen as a negative quality indicator, but might simply be a consequence of the different examination structure introduced with the Bologna reform. While in the old degree programs, most often it was only the courses taken in the second study phase and/or final diploma/magister examinations that determined the final grade, in the majority of new degree programs every examination from the first semester onwards counts towards the final grade. The better grades of master's students, on the other hand, can be explained by the selection and entry restrictions of master's programs, as usually only bachelor's students with a grade of 2.5 or better are eligible to pursue a master's degree in Germany.

To sum up, the Bologna reform in Germany successfully reduced relative study duration. Whether the Bologna reform also had an effect on the study quality, the skills acquired by students or strengthened the employability of university graduates in Germany are matters beyond the scope of this paper that still need to be determined. The labor market outcomes of bachelor's and master's graduates in Germany should be focus of future research.

Chapter 2

The Effect of University Rankings on the University Choice of Master's Students

2.1 Introduction

Besides the questions of whether to attend university at all and which major or field of study to choose, a student also has to decide which university to attend. As the literature shows that the university where a student earns his/her degree can significantly affect later labor market outcomes, for example earnings (Black and Smith, 2006; Hoekstra, 2009; Long, 2010; Ciriaci and Muscio, 2014; Eide et al., 2016; Walker and Zhu, 2018), the university choice is of key interest to students.

University rankings can serve as quality signals for prospective students as well as potential employers when graduates enter the labor market, and various studies, many from the US, reveal that prospective students indeed take note of popular university rankings when choosing a university. For example, a recent study by Meyer et al. (2017) shows that there is a discontinuous drop in the number of applications if a university drops out of the top 50 in the popular U.S. News and World Report ranking.

With the implementation of a two-tier university system under the Bologna reform, students in Germany nowadays have to choose a university not only after high school graduation but also if they wish to pursue a master's degree. This paper examines whether different university quality indicators from the CHE ranking (e.g., overall stu-

dent satisfaction, research reputation, academic publications, and international focus of the study program) have an influence on the university choice of master's students in Germany.

To my knowledge, the empirical evidence of the effect of university rankings on the university choice of students in Germany is limited to Horstschräer (2012), who examines the influence of different quality indicators of the CHE ranking on the application choice of students who want to pursue a medical degree. She finds that applicants do react to changes in the CHE quality indicators; for example, an increase in the overall student satisfaction positively influences the application choice.

However, the results of Horstschräer (2012) cannot simply be transferred to students from other fields of study, as medical study applicants in Germany are a quite select and small group, mainly consisting of very high-ability students. In addition, more experienced graduate students (those who have already acquired "study experience" from their bachelor's degree) might value ranking indicators differently than students enrolling in university for the first time. Thus, this paper contributes to the existing literature, as it is the first to examine the influence of CHE ranking indicators on the university choice of master's students from various study subjects in Germany.

For my empirical analysis I use data from the Student and Examination Statistics, an administrative data set covering all students at German universities from 2010 to 2015. The size of the data set makes it possible to relate CHE university ranking outcomes with the enrollment decisions of subgroups, for example for students in different fields of study or by gender.

I also separately examine the enrollment decisions of students with very good bachelor's grades, as most universities are especially interested in attracting the best students. As these very good students are also very likely to be admitted to their preferred university, enrollment at a given university reveals the student's true preference. This is an advantage over using application data, where the true preferences of students might not be apparent. In addition, if we assume that there are no supply-side restrictions for the very good students, the latter empirical setup enables me to explicitly examine the

demand-side effect of the CHE university ranking.

Identification stems from variation in the subject-specific CHE university ranking results over time, which allows me to include university fixed effects in the conditional logit model used for the empirical analysis. Hence, like Horstschräer (2012), I am able to distinguish between the effect of the CHE ranking indicator and the effect of the time-constant overall attractiveness and reputation of a university on the enrollment decision of students.

My findings show that the CHE university ranking indicators overall student satisfaction, research reputation, academic publications, and international focus of the study program matter for the university choice of master's students in Germany. For example, if the subject-specific university ranking for the indicator overall student satisfaction rises from the middle to the top group, the enrollment probability of a graduate student increases by around 16 percent. On the other hand, the enrollment probability decreases by around 18 percent if the university drops from the middle to the bottom group in the category overall student satisfaction.

Sample split analysis reveals that male students react more strongly to changes in the ranking indicators than do female students, and that results are mainly driven by students in the fields of business, economics, and social sciences as well as mathematics, natural sciences, engineering, and architecture. In contrast, the enrollment decisions of students from the field of linguistic sciences seem not to be influenced by the subject-specific university ranking indicator overall student satisfaction.

The remainder of this chapter is structured as follows: Section 2.2 gives an overview on the institutional background of the German higher education system. In Section 2.3, related literature is reviewed. Section 2.4 provides details on the employed data and presents descriptive statistics. Section 2.5 outlines the empirical approach and Section 2.6 presents the estimation results. Section 2.7 concludes.

2.2 Institutional Background

The German higher education system is traditionally based on public universities, and until 20 years ago there was hardly any competition and no major differences in quality between public universities in Germany. This slowly began to change when in the mid-1990s German policy makers started to set up new rules to make the financing and administration of public universities less bureaucratic and driven by ministerial requirements, but instead more autonomous and driven by individual responsibility and performance incentives (Schreiterer, 2014).

The excellence initiative is the most prominent example of how competition is fostered between universities in Germany today. It is a funding program of the German federal and state governments that was established in 2005 and is administered by the German Research Foundation (DFG) and the German Council of Science and Humanities. The main goal of the excellence initiative is to support and promote top-level research at German universities and hence increase its international visibility and competitiveness (Deutsche Forschungsgemeinschaft, 2013). In different rounds German universities could compete for additional funding and successful universities could call themselves "university of excellence".[1]

The Bologna reform is another outstanding educational policy reform with the goal of making the higher education system more competitive (Bologna Declaration, 1999). The introduction of a homogenous two-tier university system consisting of bachelor's and master's degrees as well as the introduction of the standardized European Credit Transfer System (ECTS) for courses and grades made universities' degrees, credits, and grades more comparable within countries and throughout Europe.[2]

In addition, the availability of national and international university rankings has also made differences in teaching and especially in research quality, which have developed

[1] For more information on the German excellence initiative and an overview of universities that were pronounced "universities of excellence," please refer to Appendix B.1.

[2] Before the Bologna reform Germany traditionally had a one-tier degree system in place. For further information on the Bologna reform and introduction of the two-tier university system, please refer to Section 1.1 of this dissertation.

between German universities over the last 20 years, more easily visible to prospective students. In Germany the CHE university ranking, which provides subject-specific university ratings for different quality indicators, was first published in 1998 and today is the most important and well-known university ranking in Germany.[3]

This higher transparency and increased comparability, as well as the two-tier university system, which made it possible for students to change universities for their master's degree after having successfully graduated from their bachelor, has therefore further promoted competition between universities in Germany in the last few years. This paper examines whether students in Germany do take differences in performance in teaching and research of universities, as measured by the CHE ranking, into account when choosing a university for their master's degree.

2.3 Related Literature

The majority of the literature on the influence of university rankings on the application or enrollment decision of students comes from the US, Canada, and the UK (e.g., Drewes and Michael, 2006; Griffith and Rask, 2007; Broecke, 2015; Gibbons et al., 2015; Chevalier and Jia, 2016; Meyer et al., 2017).

For instance, Broecke (2015) show that university rankings have an influence on the number of applications received by universities in the UK. Griffith and Rask (2007) show that in the US the News and World Report ranking as well as other university rankings have an influence on the number of applications of high-ability students. In a recent study, Meyer et al. (2017) reveal a discontinuous drop in the number of applications if a university drops out of the 50 America's Best Colleges of the U.S. News and World Report rankings.

As previously mentioned, the only paper examining the effect of university rankings on students' university choice in Germany that I am aware of is that by Horstschräer (2012). For her analysis of the effect of different quality indicators of the CHE ranking she uses data from the central clearing agency ZVS, which administered the university

[3] For further information on the CHE university ranking, please refer to Section 2.4.2.

application process for medicine during the observation period from 2002 to 2008.[4]

While the research-related indicators of the CHE ranking seem to have no effect on the application decision of students, other dimensions such as the student-professor ratio, the number of clinic beds, and the overall student satisfaction do influence the university choice of future medicine students. However, these different quality indicators only have a moderate influence on the university choice of students. Horstschräer (2012) finds that the most powerful determinant is the distance between the hometown of a student and the university. This result is in line with previous research, e.g., Spiess and Wrohlich (2010), who show that in Germany the distance to the nearest university at the time of high school graduation significantly affects the decision to enroll in a university.

Horstschräer (2012) also examines the effect of the German excellence initiative on the application decision of future medicine students. Universities that were awarded the status of elite institutions during the excellence initiative on average experienced an increase in applications of almost 20 percent.

Fischer and Kampkötter (2017), who also evaluate the relation between the excellence initiative and university attractiveness for students, use data from a national student survey including students from 15 different universities and various fields of study. The authors find that the German excellence initiative had a significant influence on the number of applications and enrollment of high-ability high school graduates. They also show that students perceived universities as better (better educational quality and better job market perspectives) immediately after having gained excellence status; however, after three years students' ratings had returned to previous levels.

In contrast to the findings of Fischer and Kampkötter (2017), Bruckmeier et al. (2017) do not find any positive effects of receiving excellence status on the number of first-year students enrolling at a university in the federal state of Baden-Wuerttemberg. Nonetheless, they do find that the loss of excellence status had a negative effect on the number

[4] Medicine is one of the few study subjects in Germany where the application process is managed centrally and that remains a one-study cycle degree.

of first-year students.

To sum up, while there are various studies of the effect of university rankings on students' university choice in the UK and US, evidence for Germany is limited to Horstschräer (2012), as Fischer and Kampkötter (2017) and Bruckmeier et al. (2017) only examine the effect of the German excellence initiative but not of any university ranking indicators. Hence, this paper is the first to provide evidence on the effect of CHE university ranking indicators on the university choice of students from various fields of study.

2.4 Data and Descriptive Statistics

In this section I describe the data used in the empirical analysis, namely the German Student and Examination Statistics and the data of the CHE university ranking. Then I present some descriptive statistics.

2.4.1 German Student and Examination Statistics

For the empirical analysis I use data from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), which is based on administrative student data of all German universities provided by the Research Data Centers of the Federal Statistical Office and the Statistical Offices of the Federal States ("Forschungsdatenzentrum des Bundes und der Statistischen Ämter").[5] Among others the data set contains information on the current field of study, university, degree type, and age and sex of the student as well as the field of study, final grade of previously completed undergraduate degrees, and information on the university of first enrollment in Germany.

For the empirical analysis in this paper I restrict the data to master's students enrolling in university between 2010 and 2015, and hence all later results are conditional on doing a master's degree. I abstain from including bachelor's students, as the Student and Examination Statistics provide neither any information on the applications of students to uni-

[5] Please refer to Section 1.4.1 for further information on the German Student and Examination Statistics as well as a discussion of the advantages and disadvantages of the data set.

versities, nor about their university entrance qualification ("Abitur/Hochschulzugangsberechtigung") grades. As the admission to many undergraduate study programs in Germany is restricted and mostly depends on the high school diploma grade, many undergraduate students do not end up at their preferred university or study their preferred subject. Hence, as the data set only includes information about the actual enrollment of students, it is not suitable for analyzing the university choice of undergraduate students.

This problem is less severe for master's students, because the vast majority of bachelor's graduates in Germany who want to pursue a master's degree are admitted to their preferred university.[6] In addition, the Student and Examination Statistics do include the bachelor's grade of master's students. Hence, I can also only use master's students who have very good bachelor's grades as those students most likely receive a spot in their preferred program. If we assume that the very good students do not face any supply-side restrictions, and hence the enrollment decision reveals students' true preferences, then enrollment data are actually preferable to application data, where true preferences might not be detectable.

2.4.2 CHE University Ranking

The CHE (Center for Higher Education Development) university ranking provides subject-specific ratings for universities throughout Germany. It was first published in 1998 and nowadays is accessible online as well as in the annually published magazine "Zeit Campus Studienführer". The CHE university ranking is the most important university ranking in Germany; it receives broad media coverage and is very well known among prospective students.

While the ranking is published yearly, ranking results for the specific subjects are only updated every two to three years, as listed in Table 2.1. For example, the subject-specific ranking results for business as well as for economics that were published in 2008, 2009, and 2010 all reflect the results obtained in 2008. Hence, in the period from 2010 to 2015, which is used in the later analysis, there are between two and three different

[6] More than 90 percent of bachelor's graduates are admitted to a master's program at their preferred university (Rehn et al., 2011, p.133).

ranking results for each subject-university combination in the data.

Ranking results are based on key indicators and facts provided by the respective university administration and the statistical offices as well as on student and professor survey results. The ranking indicators used in the later empirical analysis are overall student satisfaction, research reputation, academic publications, and international focus of the study programs.

In contrast to many international university rankings, the CHE university ranking does not report the precise ranking order of the universities, but only indicates whether the university scored in the top, middle, or bottom group for a certain ranking indicator. Online as well as in the printed version, universities are listed alphabetically and either receive a green (top group), yellow (middle group), or red (bottom group) label for the different ranking indicators for each subject.

While the CHE university ranking today includes more than 30 study subjects, I concentrate my analysis on the ones listed in Table 2.1. I do not include subjects with a centrally administered admission process (e.g., medicine) or subjects for which ranking results are only available for a few years because the subject has been included in the ranking only recently.

Table 2.1: Subject-Specific Update of the CHE University Rankings

	2008	2009	2010	2011	2012	2013	2014	2015
Linguistic Sciences								
German, English & Romance Studies			x			x		
Sports		x			x			x
Business, Economics & Social Sciences								
Business & Economics	x			x			x	
Politics & Social Sciences	x			x				x
Business Engineering	x			x			x	
Psychology & Education Sciences			x			x		
Mathematics & Natural Sciences								
Mathematics, Informatics, Physics		x			x			x
Chemistry & Biology		x			x			
Earth Sciences & Geography		x			x			x
Engineering & Architecture								
Industrial, Electrical, Civil Engineering			x			x		
Architecture			x			x		

Notes: Data on the CHE university ranking are from the Center for Higher Education Development (CHE).

2.4.3 Descriptive Statistics

In the empirical analysis I use all first-year, full-time and on-campus master's students at public universities included in the CHE ranking in Germany for the years 2010 to 2015. As mentioned above, only students enrolling in the study fields listed in Table 2.1 are considered.[7]

Table 2.2 shows the share of students enrolling in a university that is ranked in the top, middle, or bottom group with respect to the different ranking indicators. Around 27 percent of students enroll in a university ranking in the top group for the indicator overall student satisfaction in the respective study subject of the student. Roughly 50 percent of students enroll in a university that is ranked in the middle group and 23 percent of students chose a university in the bottom group.

While information on overall student satisfaction is available for all individual student observations, the ranking information for other indicators, unfortunately, is incomplete. In addition, please note that in the case of research reputation, the ranking is limited to the top and medium group; there is no bottom group.

Table 2.2: *Share of Students at University in the Top, Middle, and Bottom Groups*

	Student Satisfaction	Research Reputation	Academic Publications	International Focus
Top Group	0.273	0.339	0.367	0.575
Middle Group	0.496	0.661	0.493	0.392
Bottom Group	0.230	—	0.140	0.033
Observations	166,343	133,130	75,520	74,382

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), and the data on the CHE university ranking are from the Center for Higher Education Development (CHE).

[7] More than two-thirds of the first-year master's students in the original data set are enrolled in a field listed in Table 2.1.

Table 2.3 shows that there is information on the ranking outcome for overall student satisfaction available for all 3,614 university-subject combinations included in the data, while for research reputation, academic publications, and international outlook of the study program, ranking results are only available for 2,960, 1,993, and 986 university-subject combinations, respectively.

Table 2.3 also reveals that for around 40 percent of university-subject combinations, there was a change in the ranking indicator overall student satisfaction in the period between 2010 and 2015. I exploit this variation in the ranking indicator group over time in the later empirical analysis.

As in addition to the available number of university-subject combinations the variation in ranking group is also smaller for research reputation, academic publications, and international outlook of the study program, the later empirical analysis for the most part focuses on the estimation results for overall student satisfaction.

Table 2.3: *Share of University-Field of Study-Observations with Changes in Ranking Indicator Groups*

	Student Satisfaction	Research Reputation	Academic Publications	International Focus
Mean	0.401	0.017	0.348	0.157
Observations	3,614	2,960	1,993	986

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), and the data on the CHE university ranking are from the Centrre for Higher Education Development (CHE).

2.5 Empirical Strategy

This section describes the estimation strategy used to identify the effect of the CHE university ranking indicators on the enrollment decisions of master's students.

As with Griffith and Rask (2007) and Horstschräer (2012), the estimations build on a standard random utility model, where X_{ij} are student-university-specific characteristics

(distance to hometown, etc.), Z_j are university characteristics (reputation of university, etc.), and ϵ_{ij} is an unobserved random component:

$$U_{ij} = \alpha X_{ij} + \beta Z_j + \epsilon_{ij}$$

Following Horstschräer (2012), this choice model is estimated with a conditional logit model, which allows the inclusion of student-university-specific effects, e.g., the distance between the university of the student's first enrollment in Germany and the university where the student enrolled for his/her master's degree. Hence, my estimation equation reads as follows:

$$y_{ij} = \alpha Rank1_{ij} + \beta Rank3_{ij} + \gamma X_{ij} + \delta U_j + u_{ij}$$

y_{ij} is a binary variable that takes the value 1 if student i has chosen university j for his/her master's degree and 0 if not. Hence, for every individual the data set now not only needs to contain the observation where $y_{ij} = 1$, indicating that the individual actually enrolled in this university for his/her master's degree, but also one observation for every university included in the CHE ranking that offers a master's degree in the respective field of study where student i did not enroll ($y_{ij} = 0$). Therefore, the data set is expanded from 166,343 individual observations to 4,964,829 individual-university observations. On average there are around 30 individual-university observations for each student; the minimum number of observations per student is 7, the maximum 51.

$Rank1_{ij}$ and $Rank3_{ij}$ are the variables of interest in the model. $Rank1_{ij}$ is a vector of ranking outcomes indicating whether university j has ranked in the top group of a certain ranking indicator (overall student satisfaction, research reputation, academic publications, international focus) in the year when student i enrolled in a master's program. Accordingly, $Rank3_{ij}$ is a vector of ranking outcomes indicating whether university j is ranked in the bottom group of a certain ranking indicator. Hence, the baseline category in this model is the middle group, meaning that the effect on the enrollment probability of a university being in the top or bottom group is measured in comparison to a university in the middle group.

X_{ij} is a vector of all student i and university j specific variables, e.g., the distance between the university of first enrollment, which is presumably most often the university where the student did his/her bachelor's degree, and the master's university. As I observe every individual only at one point in time, i automatically defines the year of the observation. Hence, this vector also includes the university time-varying effect, a dummy that takes the value 1 if the respective university was part of the excellence initiative in the year student i enrolled in a master's program.

U_j is a university fixed effect that includes all time-invariant university-specific components, such as common knowledge of the university's attractiveness or reputation. Due to the university fixed effect U_j identification stems from variations in ranking indicator outcomes over time (see Table 2.3), and I am therefore able, like Horstschräer (2012), to disentangle the effect of the ranking outcomes from the common knowledge of the quality of a university.

2.6 Results

In this section I present my results on the effect of the CHE university ranking on the enrollment decision of master's students in Germany. First, I show results for overall student satisfaction. Second, I present results for the other ranking indicators. Third, I analyze the heterogeneity of my results with respect to gender and field of study.

Following Horstschräer (2012), the estimation results are presented as odds ratios. Hence, the exponentiated coefficients can be interpreted as a percentage change in the dependent variable y_{ij} caused by a change in the binary treatment variable $Rank1_{ij}$ or $Rank3_{ij}$ if all other independent variables are held constant. An odds ratio greater than 1 means that the effect of the treatment variable increases the enrollment probability, while an odds ratio less than 1 means that the treatment variable decreases the enrollment probability. All results are conditional on doing a master's degree.

2.6.1 Overall Student Satisfaction

Table 2.4 presents the estimation results of different specifications for the effect of overall student satisfaction on the enrollment probability. The specification in Column 4, which includes the distance between the university of first enrollment and the current university, university fixed effects, and a dummy for the excellence status as control variables, shows that if the ranking of a university-subject combination changes from the middle to the top group, the probability of a student enrolling at this university for his/her master's degree rises by 15.9 percent. On the other hand, the enrollment probability decreases by 18.2 percent if the ranking outcome changes from the middle group to the bottom group.

Including the distance between the university of first enrollment of a student in Germany, which is presumably the university where a student did his/her bachelor's degree, and the master's university has a large effect on the explanatory power of the model. The Pseudo-R^2 rises from 0.001 in the model without distance as control variable presented in Column 1 to 0.444 in the model including distance in Column 2. The main specification of Column 4 shows that if the distance between the university of first enrollment and the prospective master's university increases by 100 km, the enrollment probability is reduced by 74.1 percent. This result is in line with the results of previous studies from Germany (Spiess and Wrohlich, 2010; Horstschräer, 2012) and confirms that not only undergraduate but also graduate students are quite immobile in Germany.

As previously mentioned, estimation results might be hard to interpret if there are supply-side restrictions. Results might be biased downward if the number of students in a master's program is limited and some students are thus not admitted to their preferred, highly ranked, university. At the same time the results presented above might overestimate the demand-side effect of the CHE university ranking if, for example, some third factor, such as more funding, leads to a situation where a university increases the number of admitted students and at the same time receives a better ranking.

To test whether estimation results are biased by either restricted or extended supply, Table 2.5 presents the results for students with a very good bachelor's grade only, as it

Table 2.4: *Overall Student Satisfaction and Enrollment Probability (Odds Ratio)*

	(1)	(2)	(3)	(4)
Top Group Student Satisfaction	1.123*** (0.007)	1.153*** (0.008)	1.157*** (0.009)	1.159*** (0.010)
Bottom Group Student Satisfaction	0.912*** (0.006)	0.956*** (0.007)	0.817*** (0.008)	0.818*** (0.008)
Distance		0.233*** (0.001)	0.259*** (0.001)	0.259*** (0.001)
Uni FE	—	—	YES	YES
Excellence	—	—	—	YES
Observations	4,964,829	4,056,396	4,056,396	4,056,396
Pseudo R^2	0.001	0.405	0.444	0.444

Notes: Odds ratios are calculated as exponentiated coefficients. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), and the data on the CHE university rankings are from the Center for Higher Education Development (CHE). Robust standard errors clustered on the individual level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

Table 2.5: *Overall Student Satisfaction and Enrollment Probability (Odds Ratio): Very Good Students*

	(1)	(2)	(3)	(4)
Top Group Student Satisfaction	1.109*** (0.011)	1.115*** (0.013)	1.139*** (0.015)	1.144*** (0.015)
Bottom Group Student Satisfaction	0.881*** (0.009)	0.903*** (0.012)	0.793*** (0.012)	0.796*** (0.012)
Distance		0.298*** (0.002)	0.328*** (0.002)	0.328*** (0.002)
Uni FE	—	—	YES	YES
Excellence	—	—	—	YES
Observations	1,902,783	1,437,233	1,437,233	1,437,233
Pseudo R^2	0.001	0.315	0.384	0.384

Notes: Odds ratios are calculated as exponentiated coefficients. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), and the data on the CHE university rankings are from the Center for Higher Education Development (CHE). Robust standard errors clustered on the individual level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

can be assumed that those students do not face supply-side restrictions and are most likely admitted to their favorite university in any case.

With a 14.4 percent increase in enrollment probability if a university-subject combination moves from the middle to the top group and a 20.4 percent decrease in enrollment probability when a university-subject combination moves from the middle to the bottom group, the results in Column 4 are fairly comparable to those presented in Table 2.4. Hence, it seems that supply-side effects are not driving the estimation results neither extended supply correlated with higher rankings nor not being admitted in a master's program at the favorite university seems to be a major issue in Germany.

2.6.2 Other Ranking Indicators

Table 2.6 displays the estimation results for the other ranking indicators besides overall student satisfaction. The results in Column 1 show that the enrollment probability rises by more than 50 percent if the research reputation of a university in a certain subject rises to the top group.[8] The indicator academic publications increases enrollment probability by 10.3 percent if a university-subject changes from the middle to the top group (Column 2). On the other hand, the effect of dropping from the middle to the bottom group is not significant for the indicator academic publications. The results for the ranking indicator international focus of the study program show that enrollment probability rises by 25.7 percent if a university-subject combination shifts from the middle to the top group and falls by 16.9 percent if a university drops from the middle to the bottom group for the respective subject (Column 3).

Table 2.7 presents the estimation results for the different ranking indicators for students with a very good bachelor's grade. Results are slightly more moderate for those in the top group for research reputations and academic publications, while the results for being rated in the top group for international focus of the study program is larger for the students with a very good bachelor's grade.

[8] Please note that for the ranking indicator research reputation the ranking is limited to the top and medium group; there is no bottom group.

Table 2.6: *Other Ranking Indicators and Enrollment Probability (Odds Ratio)*

	(1)	(2)	(3)
Top Group Student Satisfaction	1.114***	1.012	1.192***
	(0.010)	(0.013)	(0.018)
Bottom Group Student Satisfaction	0.906***	0.765***	0.895***
	(0.009)	(0.011)	(0.017)
Top Group Research Reputation	1.529***	—	—
	(0.017)		
Top Group Academic Publications	—	1.103***	—
		(0.012)	
Bottom Group Academic Publications	—	0.976	—
		(0.015)	
Top Group International Focus	—	—	1.257***
			(0.016)
Bottom Group International Focus	—	—	0.831***
			(0.024)
Distance	0.264***	0.270***	0.270***
	(0.001)	(0.002)	(0.002)
Uni FE	YES	YES	YES
Excellence	YES	YES	YES
Observations	3,353,151	2,097,062	1,292,016
Pseudo R^2	0.440	0.417	0.488

Notes: Odds ratios are calculated as exponentiated coefficients. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), and the data on the CHE university rankings are from the Center for Higher Education Development (CHE). Robust standard errors clustered on the individual level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

Table 2.7: *Other Ranking Indicators and Enrollment Probability (Odds Ratio): Very Good Students*

	(1)	(2)	(3)
Top Group Student Satisfaction	1.117***	1.007	1.292***
	(0.017)	(0.020)	(0.034)
Bottom Group Student Satisfaction	0.909***	0.736***	0.835***
	(0.015)	(0.016)	(0.025)
Top Group Research Reputation	1.400***	—	—
	(0.026)		
Top Group Academic Publications	—	1.036**	—
		(0.018)	
Bottom Group Academic Publications	—	0.958*	—
		(0.023)	
Top Group International Focus	—	—	1.366***
			(0.029)
Bottom Group International Focus	—	—	0.926
			(0.044)
Distance	0.341***	0.340***	0.325***
	(0.002)	(0.003)	(0.003)
Uni FE	YES	YES	YES
Excellence	YES	YES	YES
Observations	1,182,341	786,467	453,367
Pseudo R^2	0.375	0.371	0.438

Notes: Odds ratios are calculated as exponentiated coefficients. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), and the data on the CHE university rankings are from the Center for Higher Education Development (CHE). Robust standard errors clustered on the individual level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

2.6.3 Heterogeneity

Men vs. Women

Table 2.8 displays the sample split results for male and female students. The estimation results show that male students react more strongly to changes in overall student satisfaction. The estimation results in Column 1 reveal that if for a certain subject a university rises from the middle to the top group, the enrollment probability of male students increases by 22.3 percent, while the enrollment probability of male students decreases by 23.2 if the university drops from the middle to the bottom group in the respective subject.

In contrast, the estimation results in Column 3 show that female students are only 9.4 percent more likely to enroll in a university if the group rank for the university-subject combination increases from middle to top, while the enrollment probability decreases

Table 2.8: *Overall Student Satisfaction and Enrollment Probability (Odds Ratio): Male vs. Female Students*

	(1) All Male	(2) Very Good Male	(3) All Female	(4) Very Good Female
Top Group Student Satisfaction	1.223***	1.198***	1.094***	1.090***
	(0.014)	(0.024)	(0.013)	(0.020)
Bottom Group Student Satisfaction	0.768***	0.728***	0.867***	0.854***
	(0.010)	(0.017)	(0.011)	(0.017)
Distance	0.226***	0.303***	0.298***	0.352***
	(0.002)	(0.003)	(0.002)	(0.003)
Uni FE	YES	YES	YES	YES
Excellence	YES	YES	YES	YES
Observations	2,233,134	695,169	1,823,262	742,064
Pseudo R^2	0.516	0.449	0.364	0.328

Notes: Odds ratios are calculated as exponentiated coefficients. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), and the data on the CHE university rankings are from the Center for Higher Education Development (CHE). Robust standard errors clustered on the individual level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

by 13.3 percent if the group rank for overall student satisfaction falls from middle to bottom.

The results in Columns 1 and 3, where all male and female students are included, are robust to the inclusion of only the very good male and female students, as shown in Columns 2 and 4, respectively.

The stronger reaction of male students is in line with the existing literature for the UK and US, which shows that on average males pay more attention to university rankings than do female students (e.g., Griffith and Rask, 2007; Broecke, 2015). For German medical students, Horstschräer (2012) does not find significant effects of top-group ranking indicators for male applicants. However, this might be due to the small sample size of male medical students.

Field of Study

Table 2.9 presents sample split results for the different fields of study. As shown in Columns 1 and 2, the top group rank of the CHE indicator overall student satisfaction has no influence on the enrollment probability of students in the fields of linguistic sciences and sports.

In contrast, for students in business, economics, and social sciences, the enrollment probability rises by 15.7 percent when a university-subject combination increases its rank from medium to top and falls by 8.2 percent if the rank drops from medium to bottom (Column 3). For students in the field of mathematics and natural sciences, the enrollment probability rises by 11.5 percent and falls by 29.8 percent if a university-subject combination changes from middle to the top or from the middle to the bottom group, respectively (Column 4).

For engineering and architecture students, the effect of an increase in the ranking for overall student satisfaction from the middle to the top group on enrollment probability is more than 50 percent. However, for the group of engineering and architecture students, the effect of a university-subject combination dropping from the middle to the bottom group is also positive and significant, but with a relatively small value of 5.5 per-

cent. In addition, the effect of the distance between the university of first enrollment of a student and the prospective university is much larger for engineering and architecture students than for students from other fields. Hence, for engineering and architecture students, the enrollment decision seems to be different in some way than for students from other fields of study. It seems that these students are especially immobile, and presumably they tend to stay at their bachelor's university even if the university ranking drops to the bottom group.

Anecdotal evidence suggests that this might be because engineering students are involved in projects with private companies during their studies more often than other students, for example through internships or working in student positions, or because they write their theses within a company. This would be in line with the fact that research cooperation between universities and private companies is also more common in technical fields. The share of external funds per researcher is highest in the field of engineering (Statistisches Bundesamt, 2017, p. 70). A stronger tie to possible future employers in the early stages of their studies is a possible explanation why engineering students are less mobile than students from other fields of study.

As displayed in Table 2.10, positive effects on enrollment probability are more moderate for engineering and architecture students (Column 5) when only students with a very good bachelor's grade are included in the sample. In addition, the effect of a university-subject combination dropping from the middle to the bottom group now significantly reduces the enrollment probability for students in the field of engineering and architecture, and the very good engineering and architecture bachelor's graduates are also more mobile than the average engineering and architecture student.

Table 2.9: *Overall Student Satisfaction and Enrollment Probability (Odds Ratio): Field of Study*

	(1) Linguistic Sciences	(2) Sports	(3) Bus., Econ. & Social Sciences	(4) Mathematics & Natural Sciences	(5) Engineering & Architecture
Top Group Student Satisfaction	0.976 (0.043)	0.950 (0.129)	1.157*** (0.018)	1.115*** (0.017)	1.509*** (0.035)
Bottom Group Student Satisfaction	1.056 (0.076)	0.115** (0.125)	0.918*** (0.013)	0.702*** (0.012)	1.055** (0.029)
Distance	0.281*** (0.007)	0.345*** (0.014)	0.338*** (0.002)	0.256*** (0.002)	0.137*** (0.002)
Uni FE	YES	YES	YES	YES	YES
Excellence	YES	YES	YES	YES	YES
Observations	186,630	15,431	1,387,753	1,632,729	833,853
Pseudo R^2	0.421	0.356	0.317	0.456	0.712

Notes: This table reports the effects of the ranking indicator of overall student satisfaction on enrollment probability for sample splits by field of study as indicated by the column header. Odds ratios are calculated as exponentiated coefficients. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), and the data on the CHE university rankings are from the Center for Higher Education Development (CHE). Robust standard errors clustered on the individual level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

Table 2.10: *Overall Student Satisfaction and Enrollment Probability (Odds Ratio): Field of Study, Very Good Students*

	(1) Linguistic Sciences	(2) Sports	(3) Bus., Econ. & Social Sciences	(4) Mathematics & Natural Sciences	(5) Engineering & Architecture
Top Group Student Satisfaction	1.053 (0.072)	0.785 (.)	1.128*** (0.026)	1.080*** (0.027)	1.312*** (0.061)
Bottom Group Student Satisfaction	0.912 (0.121)	1.345 (.)	0.855*** (0.019)	0.792*** (0.024)	0.776*** (0.049)
Distance	0.369*** (0.011)	0.385 (.)	0.361*** (0.003)	0.345*** (0.004)	0.215*** (0.005)
Uni FE	YES	YES	YES	YES	YES
Excellence	YES	YES	YES	YES	YES
Observations	73,080	6,490	631,158	542,298	184,207
Pseudo R^2	0.397	0.328	0.310	0.408	0.661

Notes: This table reports the effects of the ranking indicator of overall student satisfaction on enrollment probability for sample splits by field of study as indicated by the column header. Odds ratios are calculated as exponentiated coefficients. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), and the data on the CHE university rankings are from the Center for Higher Education Development (CHE). Robust standard errors clustered on the individual level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

2.7 Conclusion

This paper examines the effect of the CHE university ranking on the university choice of master's students in Germany with data from the German Student and Examination Statistics. I use variations in ranking indicators over time, which allow me to distinguish between the overall attractiveness and reputation of a university and the effect of the CHE ranking outcomes on the enrollment decisions of master's students. The estimation results of this paper reveal that scoring in the top group of the CHE ranking indicator overall student satisfaction is associated with a significant increase in the enrollment probability of prospective master's students in almost all fields of study.

The sample split results for very good students are to a great extent comparable to the overall estimation results. As it can be assumed that at least the very good students do not face any supply-side restrictions, this shows that the relation between the CHE ranking results and the enrollment decision is driven by demand-side effects.

However, please note that I cannot make any statement as to whether it is only the ranking results that influence prospective students, or whether information about student satisfaction at a university is also available to prospective students through other channels. As students in Germany are quite immobile and many students stay at their bachelor's university or a university close by, prospective students might know current students who can provide them with first-hand information on the study situation and the teaching quality and whether they can recommend the program. In addition, prospective students that do not know any current students personally, nowadays can easily obtain information from current students through social media. However, the knowledge about students' satisfaction transmitted through word of mouth presumably changes continuously, whereas the CHE ranking group changes are discrete. Hence, while estimation results cannot be solely driven by other channels, nevertheless they might be influenced by them to some extent.

Also, the other ranking indicators that are included in the empirical analysis, namely research reputation, academic publications, and international focus of the study program, are related to the enrollment decisions of students. However, here also one cannot say

whether students only rely on the ranking results or if the ranking results just present a snapshot of current common knowledge that might be acquired through other channels about the research reputation of a subject at a certain university.

In respect to the heterogeneity of the results, I find that male students react more strongly to changes in the CHE than do female students, which is in line with the results of previous studies. I also show that students from the fields of business, economics, and social sciences and of mathematics and natural sciences as well as of engineering do react to changes in the CHE ranking indicator overall student satisfaction, whereas the enrollment decisions of students in the field of linguistic sciences are not sensitive to changes in ranking results.

To sum up, this paper is the first to show that in Germany the CHE ranking results are at least strongly correlated with the enrollment decision of master's students. Whether students graduating from universities with programs with a higher ranking in a certain field have better labor market outcomes is a question that might be the focus of future research. This could be combined with an examination of whether other university rankings that are based on surveys of potential employees (e.g., the university rankings published by the German business magazine "Wirtschaftswoche") have an influence on enrollment decisions as well as on later labor market outcomes.

Chapter 3

Local Labor Market Conditions and Field of Study Choice*

3.1 Introduction

When graduating from school, students make two of the most important decisions in their lives: whether to enroll at university and what field to study. Economic and non-economic returns of higher education are substantial and field of study premiums rival the returns of college-going (Kirkeboen et al., 2016). The determinants of schooling investment and especially field of study choice are difficult to investigate, however, because credible variation in the drivers of schooling and field of study choice is rare. For this reason, most analyses of field of study choice rely on information experiments (e.g., Wiswall and Zafar, 2015; Baker et al., 2018).

What is even less well understood is how local labor market shocks translate into human capital investments. The allocation of talent across fields is especially interesting: Altonji et al. (2016) find that high-paying majors fare substantially better during recessions than low-paying majors, exacerbating the earnings gap across college majors. Also, tertiary education mitigates recession impacts on employment (Hoynes et al., 2012). If school leavers are not perfectly mobile across regions because of family ties, mobility costs, or informational barriers, local shocks may also have lasting impacts on

* This paper is based on joint work with Markus Nagler.

local economic outcomes and local human capital.

In this paper, we analyze the impact of local labor market shocks on enrollment in higher education and field of study choice. We use within-region and over-time variations in local labor market conditions to study this question. Thus, we can examine how short-run decreases in local employment opportunities influence human capital accumulation in the long run. The results have direct policy relevance: If local labor markets matter for human capital formation, the long-run impacts of local labor market shocks are different than their short-run costs.

For our empirical analysis we use the German Student and Examination Statistics, an administrative data set on the universe of students in tertiary education in Germany between 1995 and 2015. We observe both initial study choices and outcomes in repeated cross sections, such that we can distinguish between impacts on initial study choice and completed education. The data set comes at the cost of including only a few demographics, namely age and gender. However, it includes the county where students obtained their university entrance qualification ("Abitur/Hochschulzugangsberechtigung"). As this generally coincides with the county where students grew up, we can measure how shocks in local labor markets, such as increases in the unemployment rate, translate to human capital investments. We use statistical regions ("Raumordnungsregionen") as local labor markets and measure local labor market conditions through unemployment rates, following the recent literature (e.g., Altonji et al., 2016). We then build on the simple choice model developed by Blom et al. (2015) and relate the log shares of students in specific fields to these local labor market conditions.

The identifying assumption is that local labor market conditions at high school graduation are exogenous to the field of study choice, conditional on covariates. To account for broader local differences in field of study choice and overall trends, we condition our specifications on region and year fixed effects. Therefore, we identify the impacts from within-region changes in unemployment over time. Because short-run local labor market conditions are unrelated to the ability and characteristics of high school graduates, we argue that our estimates reflect causal effects.

We find that local labor market conditions indeed affect field of study choice. Students are more likely to obtain degrees in STEM subjects and business studies and less likely to obtain degrees in law, economics and social sciences. Moreover, men react more strongly to local labor market shocks, in line with findings of earlier research (e.g., Johnson, 2013). Our results are mostly driven by students from regions with below-average GDP per capita and by students from East Germany. Leveraging our detailed data, we distinguish between effects at initial enrollment and at graduation. We find the latter to be substantially more pronounced.

While we interpret the reduced-form effects as causal, the estimates do not discriminate between alternative mechanisms. On the one hand, local labor market shocks at high school graduation may change the expectations of students about the returns of different college majors. Such shocks may also highlight the riskiness of different options. On the other hand, adverse labor market conditions at high school graduation may affect students' decisions if their parents suffer income shocks. Given our results for wealthy and poor counties as well as East and West Germany as a whole, an explanation based on credit constraints rather than changes in expectations seems more likely. This is reinforced by the finding that effects are substantially more pronounced at graduation than at initial enrollment. If short-run changes in expectations of students were driving our results, we would expect the opposite differential effect, if any. However, our setting limits us from providing more comprehensive evidence on potential mechanisms.

We complement the literature on long-run impacts of macroeconomic shocks and human capital investments. In recent years, a vibrant strand of research has documented impacts of macroeconomic conditions on workers who started their careers during times of crises (Kahn, 2010; Liu et al., 2015; Oreopoulos et al., 2012). The flip side to these "scarring effects" is the change in occupational choice during recessions (e.g., Oyer, 2008; Shu, 2012; Boehm and Watzinger, 2015; Nagler et al., 2015). However, it is unclear how these effects translate to individuals who have yet to decide whether and how to invest in an important part of their human capital. A major challenge in analyzing the determinants of such schooling investments usually is to find credible variation in

the costs and benefits of schooling.[1] Blom et al. (2015) use time series business cycle variation and the American Community Survey (ACS) to show that during economic downturns, students are more likely to choose high-paying fields. Liu et al. (2017) also use the ACS data and find that in the great recession, students shied away from finance and business majors. And Hampf et al. (2017) use cross-country regressions and the PIAAC data to show that individuals who graduate during recessions have higher numeracy and ICT skills and higher college enrollment. We provide two main contributions to this literature.

First, we show that *local* labor market conditions matter for educational investments. While much of the literature on the long-run impacts of graduating during a recession focuses on broader regional or even nation-wide business cycle conditions, the impact of *local* economic shocks on long-run labor market outcomes is not well understood. This is in spite of recent studies emphasizing the importance and persistence of local labor markets (e.g., Amior and Manning, forthcoming). An exception is Stuart (2017), who uses census data to assess how the 1980-82 recession affected long-run education outcomes and incomes.[2]

Second, we complement the literature by using administrative data on the *universe* of students in higher education in Germany over 20 years. While previous papers mostly rely on survey data and only observe completed education, our data allow us to compare impacts on initial study choice and on study outcomes as well. Therefore, our setting contributes to the literature by combining credible and frequent exogenous variation with extensive observational data.

This chapter proceeds as follows: Section 3.2 details the data and 3.3 the empirical setup. Section 3.4 presents our results. Section 3.5 discusses our results and limitations of our analysis. Section 3.6 concludes.

[1] Many scholars therefore turn to information experiments to study this question (Wiswall and Zafar, 2015). While this approach gives important insights into the mechanisms behind college major choice, it is unclear how these effects translate from the lab to naturally occurring settings.

[2] He leverages variation in recession intensity between counties in a difference-in-differences framework. However, his research focuses on a single recession and ignores field of study choice. In contrast, our design provides detailed and accurate information on the type of human capital that graduates pursue and uses frequent region-level unemployment shocks for identification.

3.2 Data and Descriptive Statistics

In this section, we describe the administrative data sources that we use for our main analysis. We also present the descriptive statistics of our main variables.

3.2.1 German Student and Examination Statistics

We have access to the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), which are based on administrative data from all German institutions of higher education (hereafter, "universities") since 1995. The data consist of a full student census in the winter terms and of first-year students and graduates only in the summer terms.

The data set contains information on basic student characteristics as well as study and graduation-relevant information such as the year and county of university entrance qualification, university of enrollment, exact term, field of study, length of study (total semesters and subject-related semesters studied), degree obtained, and final overall grade (on a five-step scale from "very good" to "not passed").

In contrast to the United States and some other countries, students in Germany are admitted to only one field of study at a university and cannot decide on their major while enrolled at the university. For our initial field of study choice analysis, we restrict our sample to students enrolled at a German university for the very first time.

In addition, we aggregate the exact course of study to meaningful broader fields because regional variation would otherwise imply observations with a dependent variable that is truncated from below. Because only those students who do not pass their final exam are marked "not passed" and those who drop out earlier are not, we only use information on students who graduated successfully. To be able to measure both initial enrollment and graduation rates in similar cohorts, we omit all students who obtained their university entrance qualifications after 2010.

Our data are an interesting complement to previous data sources in the literature. Its breadth and accuracy add to papers using survey-based data such as the American Com-

munity Survey employed in Blom et al. (2015) or Liu et al. (2017). Also, the sample size is very large and non-representativeness or non-response are of little concern as universities are obliged by law to collect the respective data.[3] However, the data come with the caveat that the information on student characteristics is sparse. Most importantly, they do not include ability measures such as the grade on the university entrance qualification or cognitive test scores. Because student identifiers are unavailable due to data protection regulations, it is also not feasible to track individual students' progress through their university career or use student fixed effects.

We merge this data with public data on local economic indicators such as unemployment rates and population information. These data are aggregated from county data from the German statistical offices. We use the definition of local labor markets used by the statistical offices ("Raumordnungsregionen," "regions" hereafter), which are comparable to metropolitan statistical areas in the United States. There are 96 such regions in Germany.

We subsequently leverage the available student data on the university entrance qualification to determine whether students experienced local labor market shocks upon high school graduation. Because the county of the university entrance qualification usually coincides with (or is very close to) the county of residence, we use the unemployment rate in the year and region of the county of the university entrance qualification as our preferred measure of local labor market shocks.

3.2.2 Descriptive Statistics

Table 3.1 shows the descriptive statistics. The average regional unemployment rate is around 10 percent in this time period. The upper panel then shows summary statistics for the initial study choice.

[3] Higher Education Statistics Act ("Hochschulstatistikgesetz, HStatG"), November 2nd, 1990

Table 3.1: *Summary Statistics*

	Initial Study Choice			
	Mean	Std. Dev.	Min.	Max.
Unemployment	9.71	4.89	2.60	36.79
Law	4.40	1.40	1.05	13.13
STEM	35.64	3.87	23.75	49.23
Arts & Humanities	10.37	2.27	2.36	18.69
Economics & Social Science	12.00	2.35	6.39	21.85
Business	17.03	2.72	9.85	28.49
Teaching	13.17	4.13	3.00	25.79
Health & Medicine	6.74	1.45	0.51	12.28
Sports	0.65	0.34	0.00	2.23
Mobile	33.97	17.04	6.09	82.68
University	61.94	7.78	17.62	87.66
	Study Outcomes			
	Mean	Std. Dev.	Min.	Max.
Law	4.25	1.89	0.00	13.04
STEM	33.41	4.48	21.28	57.14
Arts & Humanities	10.08	2.28	3.02	20.08
Economics & Social Science	12.35	3.20	5.56	41.86
Business	16.22	2.63	9.24	31.58
Teaching	14.98	4.88	3.30	31.91
Health & Medicine	7.87	1.96	0.00	16.10
Sports	0.83	0.44	0.00	2.51
Total Semesters	10.71	1.48	6.57	13.93
Subject-Related Semester	9.65	1.19	6.42	11.93
Mobile	36.04	17.96	5.76	86.80
University	60.53	7.60	14.29	86.04
Observations	1,387			

Notes: Summary statistics of main variables with region*years as units of observation. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on business cycle conditions from the Regional Database Germany ("Regionaldatenbank Deutschland").

Around 4 percent of students choose law when they first enroll at university. Over 35 percent study STEM subjects, and around 10 percent each study arts and humanities or economics and social science. A little under 17 percent enroll in business administration and 7 percent in health and medicine. Around 13 percent of students choose fields of study to become a teacher. More than a third of students are mobile, defined as studying in a different state than their state of high school graduation. Of all students enrolling in German higher education institutions, more than 60 percent are enrolled at proper universities.

The bottom panel shows the summary statistics of our final sample of students finishing higher education. In addition to the field of study shares, which are very similar, this table also includes study outcomes. The average student spends around 11 semesters (5.5 years) at universities (total semesters), of which around 10 semesters are in the field that students finish (subject-related semesters).

3.3 Empirical Strategy

Our setup is closely related to Blom et al. (2015), who show that the log shares of students in certain fields can be related to business-cycle characteristics through a simple choice model. In contrast to their research, we use region-year-level observations of field of study choice and unemployment shocks. Because we estimate equations separately by field, we do not include field-specific fixed effects.

Adjusting their estimation equation to our setup, we arrive at the log-linearized equation:

$$log(S_{rym}) = \mu_y + \beta_m \cdot unemp_{ry} + \alpha_r + \epsilon_{irym}$$

where $log(S_{rym})$ denotes the log share of students from region r in graduation year y choosing field of study m. μ_y and α_r denote cohort and region fixed effects, respectively. In this equation, β_m is the coefficient of interest. It shows how an increase in the regional unemployment rate changes the log share of students from this high school graduation cohort studying the specific subject. We cluster standard errors at the regional level to allow for arbitrary correlation patterns across time (Bertrand et al., 2004).

In contrast to the specification in Blom et al. (2015), we rely on the variations of unemployment rates within regions across years. Thus, through our year fixed effects we can control for cohort-specific trends in field of study choice and only have to assume that these do not vary by region-cohort-field level. The identifying assumption is therefore that, conditional upon region and major cohort-specific fixed effects, the unemployment rate at graduation is exogenous to other changes in the relative utility of college majors or cohort characteristics. As we interpret the variation in unemployment as reflecting changes in local labor demand and the reverse causality is not feasible, this identifying assumption seems plausible.

Local labor market shocks are exogenous from the perspective of graduating students but are likely to influence their decisions. The main mechanisms behind an impact of recessions on human capital investments that have been proposed in the literature thus far distinguish between two (non-exclusionary) mechanisms: on the one hand, local labor market shocks at graduation may change the expectations of students about the returns of different college majors. Such shocks may also highlight the riskiness of different options. On the other hand, adverse labor market conditions at high school graduation may decrease the ability to pay to remain in school or to choose other fields of study. They may, for example, affect students' decisions because their parents suffer income shocks and are credit constrained. We will attempt to discriminate between these mechanisms by analyzing the heterogeneity of effects along general regional economic conditions.

3.4 Results

In this section, we present our results on the impact of local labor market conditions on field of study choice and educational outcomes. First, we show the impact of local labor market conditions on "extensive margin" outcomes, such as whether and where students attend university. Second, we present results concerning the effects of local unemployment on field of study choice and completion. Third, we analyze the heterogeneity of results with respect to gender and home region characteristics.

3.4.1 Extensive Margin

We begin by estimating the impact of local labor market conditions on the extensive margin of initial choices, namely whether and where students attend university. The first column of Table 3.2 shows that under higher unemployment, the young population of a region is significantly less likely to attend higher education. While this result may be surprising at first, it is in line with recent work by Liu et al. (2017). The effect is small, however: A one-percentage-point increase in the unemployment rate translates to a decrease in the share of the young population attending higher education of around 0.1 percent. This is less than one percent of the baseline likelihood of attending higher education.[4] The second column shows that under conditions of higher unemployment, students select away from attending fully academic universities, favoring other institutions such as universities of applied sciences. This points to a shift in the direction of human capital accumulation towards being more practical and less academic. Finally, the third column shows that students are significantly more likely to attend higher education in a different state than their high school graduation.

We also estimate the impact of local labor market conditions on the extensive margin of completed degrees. Column 1 in Table 3.3 shows that the share of individuals among the young population of the home region finishing higher education decreases significantly when unemployment at the time of high school graduation increases. This effect, however, is smaller than the impact of unemployment on initially attending higher education. Graduates seem to be less likely to have studied at a proper university, but do not seem to be more or less mobile (Columns 2 and 3). Interestingly, the numbers of semesters that students spend both at university (total semesters) and studying towards their degrees (subject-related semesters) do not change significantly (Columns 4 and 5), nor do their final grades (Column 6). This suggests that the marginal students who do

[4] The dependent variable in this specification divides the number of students in our sample by the young population in their home region, which is taken from the statistical office. Because the latter is not available for all regions in all years, the number of observations is lower than in the other two columns. The German Statistical Offices show rates of attending higher education on the state level (where more accurate data is available) of 25-60 percent of each cohort, depending on the state and year of high school attendance.

not complete degrees in response to higher unemployment at high school graduation are neither more nor less successful than those who do continue in higher education.

Table 3.2: *Extensive Margin: Initial Choice*

Dependent:	Share in Tertiary Educ.	Share at University	Share Mobile
	(1)	(2)	(3)
Unemployment	-0.105***	-0.389***	0.426**
	(0.032)	(0.124)	(0.174)
Mean Dep.	12.979	61.938	33.974
Region FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	1,266	1,387	1,387
Adjusted R^2	0.902	0.798	0.953

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on business cycle conditions from the Regional Database Germany ("Regionaldatenbank Deutschland"). Standard errors clustered on the regional level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

Table 3.3: *Extensive Margin: Completed Degrees*

Dependent:	Share Young Pop.	Share at University	Share Mobile	Total Semesters	Subject Rel. Semesters	Final Grade
	(1)	(2)	(3)	(4)	(5)	(6)
Unemployment	-0.060**	-0.261**	-0.129	-0.014	-0.001	-0.259
	(0.027)	(0.109)	(0.176)	(0.011)	(0.009)	(0.282)
Mean Dep.	7.268	60.533	36.039	10.713	9.655	206.329
Region FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	1,266	1,387	1,387	1,387	1,387	1,387
Adjusted R^2	0.886	0.771	0.938	0.956	0.959	0.635

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on business cycle conditions from the Regional Database Germany ("Regionaldatenbank Deutschland"). Standard errors clustered on the regional level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

3.4.2 Field of Study Choice

We now turn to our main analysis of interest: the impacts of local labor market conditions on field of study choice. The upper panel of Table 3.4 shows the results of estimating our main specification using the initial field of study choice. The table shows that students are significantly less likely to study law and somewhat more likely to study health and medicine-related subjects when they graduate from high school during times of relatively high unemployment. All other coefficients are insignificantly different from zero. The effect sizes are small: A one-percentage-point increase in the unemployment rate translates to a 0.02 percent decrease in the share of students in law subjects.[5]

The bottom panel turns to the impact of regional unemployment at high school graduation on the composition of completed degrees across fields. In comparison to the upper panel, the effects are substantially more pronounced. When unemployment is high, students are more likely to complete STEM and business subjects and less likely to graduate in law or in economics and social sciences. A one-percentage-point change in the unemployment rate changes log shares by up to 0.04 percent. A one-standard-deviation change in the unemployment rate (5 percentage points) would thus decrease the share of students finishing law degrees by 0.2 percent and increase the share of students finishing STEM degrees by 0.05 percent. These results are somewhat smaller than but within the range of effect sizes that Blom et al. (2015) find for the United States using time series variation. The contrast to the upper panel is interesting: given that field of study shares do not seem to be initially impacted but only at graduation, an explanation of changes in the type of human capital students pursue based on a change in initial expectations is unlikely. In contrast, lasting changes in the economic environment of students (e.g., changes in parental resources) seem a more natural explanation.

The effect size for STEM subjects is in line with but substantially smaller than reported by Liu et al. (2017) for the great recession and by Blom et al. (2015). It is also in line with the results from Shu (2016), who uses data on graduates of the Massachusetts

[5] Note that the numbers of observations are lower in the last column because there are regions where no students chose sports-related fields in some years. We thus cannot compute its log share.

Institute of Technology (MIT) to find that the Great Recession shifted MIT graduates toward STEM majors. In contrast to her results, however, we find positive coefficients for completed business degrees. To disentangle the effect of regional unemployment on the wide area of STEM subjects and to compare our estimates to Liu et al. (2017), we investigate the effect on different fields within STEM (Table 3.5). The first column repeats our baseline estimate from the previous table. The remainder of the table splits the effects using the log shares of students pursuing degrees in engineering, physics, chemistry, biology, math, computer science, and other natural sciences. The upper panel shows the results using initial study choice. Again, we cannot detect large shifts in the distribution of students across fields. In the bottom panel, we again show results using completed degrees. The effects are now substantially larger and driven by engineering, physics, and math. This is somewhat different than in the sample of Liu et al. (2017), where the effects are driven by computer sciences and engineering. They do not find effects for physics and math, however.

To gauge whether our results depend on our preferred measure of local labor market conditions, we estimate the impact of different potential measures on the log share of students completing STEM subjects. We present the results in the appendix (Table C.1). We use lead and lagged unemployment, unemployment changes, and three- and five-year moving averages around graduation, as well as regional GDP and income measures. We also look at different regional entities, namely states and districts. Irrespective of the exact measure, higher regional unemployment at or around high school graduation impacts the log share of students completing STEM subjects similarly. The GDP and income measures have signs in the right direction, but the coefficients are less precise. Finally, the impact of labor market conditions on field of study choice seems substantially larger at the state level. There, a one-percent increase in the state level unemployment rate increases the log share of students completing STEM subjects by 0.017 percent. This comes at the expense of only 16 cross sectional units of observation in the panel, leaving doubts about the inference. Overall, our results do not seem to hinge on the exact measure of local labor market conditions. Thus, we continue using the measure most common in the literature.

Table 3.4: *Local Unemployment and Field of Study Choice*

Dependent:	**Log(Share ...) Initial Choice**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	0.002	-0.001	0.001	0.002	-0.023**	-0.009	0.009**	-0.011
	(0.002)	(0.007)	(0.003)	(0.004)	(0.009)	(0.007)	(0.004)	(0.015)
Mean Dep.	35.654	10.292	12.099	17.093	4.468	12.974	6.759	0.662
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,387	1,387	1,387	1,387	1,387	1,387	1,387	1,380
Adjusted R^2	0.748	0.562	0.671	0.597	0.691	0.600	0.513	0.468
Dependent:	**Log(Share ...) Completed**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	0.009***	0.001	-0.016**	0.010***	-0.042***	-0.000	0.004	-0.021
	(0.003)	(0.009)	(0.007)	(0.003)	(0.012)	(0.007)	(0.005)	(0.014)
Mean Dep.	33.467	9.996	12.427	16.269	4.342	14.765	7.895	0.838
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,387	1,387	1,387	1,387	1,386	1,387	1,386	1,364
Adjusted R^2	0.694	0.476	0.651	0.580	0.719	0.669	0.588	0.377

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on business cycle conditions from the Regional Database Germany ("Regionaldatenbank Deutschland"). Standard errors clustered on the regional level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

Table 3.5: *Local Unemployment and Field of Study Choice: Within STEM*

Dependent:	**Log(Share ...) Initial Choice**							
	STEM	Engineering	Physics	Chemistry	Biology	Mathematics	Comp. Sciences	Other
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	0.002	-0.001	0.015*	0.000	0.017	0.011	-0.001	0.004
	(0.002)	(0.002)	(0.008)	(0.011)	(0.014)	(0.009)	(0.005)	(0.008)
Mean Dep.	35.654	19.123	1.374	1.811	2.165	1.722	6.320	3.140
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1387	1387	1385	1384	1387	1384	1387	1387
Adjusted R^2	0.748	0.759	0.486	0.518	0.347	0.629	0.768	0.751
Dependent:	**Log(Share ...) Completed**							
	STEM	Engineering	Physics	Chemistry	Biology	Mathematics	Comp. Sciences	Other
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	0.009***	0.013***	0.033***	0.010	0.005	0.028**	-0.001	0.005
	(0.003)	(0.004)	(0.006)	(0.008)	(0.008)	(0.013)	(0.004)	(0.006)
Mean Dep.	33.467	18.540	1.261	1.537	2.285	1.343	5.193	3.309
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1387	1387	1377	1376	1386	1375	1387	1387
Adjusted R^2	0.694	0.674	0.400	0.389	0.330	0.514	0.657	0.713

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on business cycle conditions from the Regional Database Germany ("Regionaldatenbank Deutschland"). Standard errors clustered on the regional level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

In summary, we find significant impacts of local labor market conditions at high school graduation on field of study completion. These effects are substantially larger than for initial field of study choice, casting doubts on explanations focusing on changing expectations during recessions.

3.4.3 Heterogeneity

Men vs. Women

Men and women show considerable differences in higher education choices and also put different weights on different aspects of higher education (Zafar, 2013). To see whether men and women also respond differentially to local conditions, we repeat our main analysis for men and women separately.

The upper panels of Tables 3.6 and 3.7 show the results of this exercise using initial study choice. Overall, these results do not differ substantially from the baseline results. The only major difference is that men are significantly more likely to study subjects in the field of arts and humanities when unemployment increases. The bottom panels of Tables 3.6 and 3.7 show our results using completed degrees. In comparison to their initial choices, men are significantly less likely to complete subjects in law and in economics and social sciences and more likely to complete STEM subjects and business. Female students, on the other hand, are less likely to complete sports and more likely to complete health and medicine-related subjects. Overall, the impacts are substantially larger for men than for women.

Table 3.6: *Local Unemployment and Field of Study Choice: Men*

Dependent:	**Log(Share ...) Initial Choice**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	0.000	0.009*	0.003	0.004	-0.038***	-0.001	-0.001	-0.007
	(0.002)	(0.005)	(0.004)	(0.005)	(0.006)	(0.009)	(0.006)	(0.013)
Mean Dep.	51.008	6.304	9.488	18.106	3.832	6.617	3.890	0.755
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,387	1,387	1,387	1,387	1,386	1,386	1,386	1,346
Adjusted R^2	0.813	0.524	0.651	0.611	0.705	0.505	0.595	0.406
Dependent:	**Log(Share ...) Completed**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	0.005*	0.009	-0.015*	0.013***	-0.071***	-0.004	-0.006	-0.008
	(0.003)	(0.007)	(0.008)	(0.003)	(0.008)	(0.007)	(0.008)	(0.016)
Mean Dep.	49.905	6.196	9.783	17.726	4.047	6.765	4.619	0.959
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,387	1,387	1,387	1,387	1,380	1,386	1,384	1,326
Adjusted R^2	0.789	0.405	0.542	0.535	0.713	0.612	0.661	0.339

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on business cycle conditions from the Regional Database Germany ("Regionaldatenbank Deutschland"). Standard errors clustered on the regional level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

Table 3.7: *Local Unemployment and Field of Study Choice: Women*

Dependent:	**Log(Share ...) Initial Choice**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	-0.001	-0.004	0.003	0.001	-0.014	-0.006	0.012***	-0.021
	(0.005)	(0.009)	(0.003)	(0.004)	(0.011)	(0.007)	(0.004)	(0.013)
Mean Dep.	19.346	14.544	14.835	15.926	5.120	19.872	9.790	0.567
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,387	1,387	1,387	1,387	1,387	1,387	1,387	1,320
Adjusted R^2	0.597	0.461	0.594	0.629	0.493	0.650	0.424	0.290
Dependent:	**Log(Share ...) Completed**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	0.004	0.003	-0.011	0.007	-0.022	0.009	0.010**	-0.037***
	(0.004)	(0.012)	(0.007)	(0.005)	(0.015)	(0.007)	(0.005)	(0.014)
Mean Dep.	18.258	13.458	14.772	14.878	4.902	22.229	10.779	0.724
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,387	1,387	1,387	1,387	1,386	1,387	1,386	1,277
Adjusted R^2	0.603	0.400	0.595	0.625	0.561	0.703	0.510	0.230

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on business cycle conditions from the Regional Database Germany ("Regionaldatenbank Deutschland"). Standard errors clustered on the regional level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

East vs. West Germany

We repeat our main analysis for East and West Germany separately, as both regions are still very different and students may therefore react differently to changes in local labor market conditions. For example, East Germans are substantially more likely to move away from their home towns. In addition, East German regions are poorer than West German regions. Tables 3.8 and 3.9 show the results for West and East Germany, respectively. In their initial choices, West German students react very little to adverse local labor market conditions. In contrast, East German students seem to react much more strongly to changes in local labor market conditions. They are significantly less likely to study subjects in arts and humanities, less likely to pursue a teaching degree, and more likely to study business. In the bottom panels of Tables 3.8 and 3.9, we repeat our analysis for study completion. Again, students from West Germany react less to local labor market conditions. They are only significantly more likely to study business subjects. In East Germany, the negative impact on the log share of students completing degrees in the arts and humanities stands out.

These results are especially interesting because, as mentioned above, East German students are more likely to leave their home regions than are West German students. Thus, the changes in field of study choice are unlikely to be driven by changes in expectations about finding work locally. An alternative explanation of changes in available funds through credit-constrained parents again seems more plausible in light of the results.

Table 3.8: *Local Unemployment and Field of Study Choice: West Germany*

Dependent:	**Log(Share ...) Initial Choice**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	-0.001	0.029	0.018*	-0.002	-0.010	-0.026	-0.002	0.071*
	(0.005)	(0.020)	(0.010)	(0.007)	(0.011)	(0.030)	(0.010)	(0.040)
Mean Dep.	35.142	10.324	11.593	17.165	4.519	14.117	6.564	0.577
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,110	1,110	1,110	1,110	1,110	1,110	1,110	1,104
Adjusted R^2	0.743	0.568	0.638	0.636	0.705	0.542	0.666	0.380
Dependent:	**Log(Share ...) Completed**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	-0.013	0.040	-0.006	0.021***	-0.009	-0.002	0.006	0.059
	(0.008)	(0.025)	(0.013)	(0.008)	(0.018)	(0.028)	(0.011)	(0.047)
Mean Dep.	32.731	10.137	11.805	16.177	4.495	16.137	7.727	0.791
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,110	1,110	1,110	1,110	1,110	1,110	1,110	1,098
Adjusted R^2	0.740	0.462	0.632	0.598	0.722	0.627	0.676	0.352

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on business cycle conditions from the Regional Database Germany ("Regionaldatenbank Deutschland"). Standard errors clustered on the regional level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

Table 3.9: *Local Unemployment and Field of Study Choice: East Germany*

Dependent:	**Log(Share ...) Initial Choice**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	-0.001	-0.012**	0.002	0.008**	-0.004	-0.012***	0.004	-0.045***
	(0.001)	(0.006)	(0.003)	(0.003)	(0.011)	(0.003)	(0.005)	(0.010)
Mean Dep.	37.377	10.183	13.799	16.849	4.298	9.126	7.417	0.950
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	277	277	277	277	277	277	277	276
Adjusted R^2	0.739	0.603	0.647	0.604	0.671	0.661	0.342	0.481
Dependent:	**Log(Share ...) Completed**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	0.003	-0.020***	0.005	0.010**	-0.017	-0.006	-0.000	-0.039***
	(0.002)	(0.005)	(0.005)	(0.004)	(0.012)	(0.005)	(0.005)	(0.011)
Mean Dep.	35.945	9.522	14.520	16.578	3.828	10.147	8.461	1.000
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	277	277	277	277	276	277	276	266
Adjusted R^2	0.562	0.583	0.536	0.620	0.645	0.641	0.360	0.313

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on business cycle conditions from the Regional Database Germany ("Regionaldatenbank Deutschland"). Standard errors clustered on the regional level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

Poor vs. Wealthy Regions

We now examine this potential channel more directly. To this end, we split the sample along the mean GDP per capita in a region. If changes in field of study choice were primarily driven by changes in expectations, we should not observe large differences between these samples. If, however, the impacts are mainly driven by changes in availability of funds, then the impacts should be heterogeneous across wealthy and non-wealthy regions. Tables 3.10 and 3.11 show the results of our analysis. As these make clear, the impacts are substantially more pronounced in poor regions. The effects on the log share of students in STEM and in law are driven by this sample.

In summary, the effects are primarily driven by students from regions with below-average GDP per capita and by students from East Germany. This points towards a decreasing ability to pay or credit constraints rather than changes in expectations as the main mechanisms behind the impact of local labor market conditions on initial field of study choice. This is compatible with recent findings on the impact of personal earnings shocks on study success (Ost et al., 2018).

Table 3.10: *Local Unemployment and Field of Study Choice: Wealthy Regions*

Dependent:	**Log(Share ...) Initial Choice**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	0.000	0.017	0.014	0.009	-0.002	-0.031	0.018*	0.027
	(0.005)	(0.018)	(0.017)	(0.011)	(0.013)	(0.036)	(0.010)	(0.053)
Mean Dep.	34.837	10.635	11.657	17.361	4.693	13.479	6.754	0.583
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	585	585	585	585	585	585	585	584
Adjusted R^2	0.827	0.754	0.664	0.627	0.762	0.631	0.709	0.461
Dependent:	**Log(Share ...) Completed**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	-0.008	0.030	-0.003	0.014*	-0.017	0.000	0.015	0.017
	(0.012)	(0.018)	(0.018)	(0.008)	(0.020)	(0.030)	(0.012)	(0.047)
Mean Dep.	32.276	10.353	11.940	16.763	4.658	15.199	8.029	0.783
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	585	585	585	585	585	585	585	581
Adjusted R^2	0.799	0.635	0.711	0.584	0.773	0.687	0.727	0.419

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on business cycle conditions from the Regional Database Germany ("Regionaldatenbank Deutschland"). Standard errors, clustered on the regional level, are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

Table 3.11: *Local Unemployment and Field of Study Choice: Poor Regions*

Dependent:	**Log(Share ...) Initial Choice**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	0.002	0.000	-0.003	0.001	-0.023**	-0.008	0.009**	-0.009
	(0.002)	(0.009)	(0.003)	(0.005)	(0.011)	(0.007)	(0.005)	(0.018)
Mean Dep.	36.213	10.056	12.401	16.908	4.315	12.628	6.763	0.716
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	802	802	802	802	802	802	802	796
Adjusted R^2	0.670	0.453	0.671	0.582	0.632	0.584	0.431	0.468
Dependent:	**Log(Share ...) Completed**							
	STEM	Arts & Humanities	Economics & Social Sciences	Business	Law	Teaching	Health & Medicine	Sports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unemployment	0.010**	-0.002	-0.014*	0.011***	-0.043***	-0.002	0.001	-0.013
	(0.004)	(0.011)	(0.008)	(0.003)	(0.014)	(0.007)	(0.006)	(0.018)
Mean Dep.	34.283	9.752	12.761	15.931	4.126	14.467	7.804	0.876
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	802	802	802	802	801	802	801	783
Adjusted R^2	0.593	0.450	0.604	0.555	0.674	0.661	0.512	0.377

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on business cycle conditions from the Regional Database Germany ("Regionaldatenbank Deutschland"). Standard errors clustered on the regional level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

3.5 Discussion and Limitations

In this section, we discuss our results and argue that they are more compatible with some potential mechanisms than others, and then we provide a detailed discussion of our main limitations.

Discussion

Local labor market shocks at high school graduation may change the expectations of students about the returns of different college majors. This is especially true if students wish to work in their home region upon graduation. Adverse labor market conditions at graduation may also affect field of study choice through students' ability to pay. If students or their parents are credit constrained, adverse local labor market conditions may make it harder for some students to complete their degree.

While we cannot discriminate between these potential mechanisms directly, the patterns in our results point towards decreasing ability to pay or credit constraints as the main mechanism behind our effects. First, if changes in expectations were driving our results, we should observe similar patterns for initial study choice and for completed education. We find the opposite, which is not in line with short-run labor market fluctuations affecting expectations directly. Second, if the composition of students were to change due to changing opportunity costs when local labor markets are slack, we would expect more students to choose higher education during economic downturns. After all, the main alternative for high school graduates with a university entrance qualification is to pursue an internship. We find that the opposite is true in our data. In addition, this change in the composition of students should also affect field of study choices initially and not only at completion. Third, our results are stronger for East than for West Germany. They are also substantially stronger for poor than for wealthy regions. These results are less compatible with an explanation based on changes in expectations. They are, however, in line with a lower ability to pay for higher education driving our results.

Limitations

This study has some limitations that future research may address, as both of our main contributions also have drawbacks.

With respect to our first contribution, studying *local* labor market shocks in our setting imposes challenges. Empirically, there may be unobserved differences in the perceived utility of studying certain subjects between regions. There may also be differences in the perceived utility of certain fields over time, for example because some fields gain prominence. To account for both effects, we condition our regressions on region and year fixed effects. This comes at the expense of eliminating much of the variation in local labor market conditions between regions and over time. The remaining shocks are relatively small and thus should impact human capital formation less than long-lasting labor market shocks. This effect would, however, be of even more interest, given recent contributions to labor economics (e.g., Autor et al., 2016; Amior and Manning, forthcoming). One possibility of extending our setup would be to use plant closures for identification (e.g., Jacobson et al., 1993). However, identifying such plant closures in the German context is challenging. Recent papers use social security data from the IAB to do so (Gathmann et al., 2017). Unfortunately, it is not possible to merge information from this data with our data set for data protection reasons.

Regarding our second contribution, using administrative data on the *universe* of students in higher education allows us to compare impacts on initial study choice and on study outcomes. However, the use of this data set also has drawbacks. First and foremost, the data do not include individual characteristics such as ability or parental background. This makes it impossible to study changes in the selection into higher education in more detail. If we had access to such data, we could for example analyze whether the ability composition of students in higher education changes substantially. This would help to discriminate between changes in the field of study choices of students who would attend higher education in any case from changes in the composition of students attending higher education and thus allow a clearer interpretation of our coefficients. Also, we could study the impacts by parental background, which would yield important insights into the mechanisms behind our effects. With our setup and data, the

reduced-form effects we present are sometimes unsatisfactory and only provide an initial answer to the research question. In the future, we will make use of additional data sets such as the National Educational Panel Study (NEPS) that may allow us to shed more light on potential mechanisms. These data, however, have the same drawbacks as do survey data from other countries.

Second, the nature of our data prevents us from estimating a proper "extensive margin" effect of local labor market conditions, because we only observe enrolled students in our main data set. We currently match data from the statistical offices on school leavers and the young population with this data to account for this. However, the accuracy of this data on the county level (the level from which we aggregate our data) is unclear. For example, when using the number of school leavers with a university entrance qualification as the denominator, we consistently see higher education shares of over 100 percent. This seems to come from an unclear assignment of school leavers to regions. The young population in any region, however, is an unsatisfactory denominator, as the interpretation of the coefficient is unclear. After all, the share of students pursuing the university entrance qualification could change in response to local labor market shocks as well.

Third, we cannot assess whether some alternative mechanisms are driving our results. For example, we would be interested in seeing whether the effects on final outcomes are driven by congestion in some fields of study. Also, we would be interested in seeing whether our effects depend on how universities respond to increases in applications. Finally, the availability of alternative choices such as vocational training spots would also be an interesting alternative mechanism. Unfortunately, answering these questions is outside the scope of this paper.

3.6 Conclusion

This paper provides evidence that local labor market shocks matter for human capital formation. We build on the basis of Blom et al. (2015) to show that higher unemployment at graduation impacts field of study choice. These results are mostly driven by students from poor regions, suggesting limited ability to pay as a potential mechanism.

We use administrative data on the *universe* of students in higher education in Germany to provide these results. We can thereby provide a more complete picture of the impacts of labor market shocks on human capital formation. For example, our data set provides the additional advantage that we can distinguish between effects at enrollment and at graduation, with the latter substantially more pronounced. This again suggests that limited ability to pay rather than changes in expectations is a more plausible explanation for the effects we find.

Finally, we are the first to study the impact of *local* labor market shocks on field of study choice. We show that regional shocks have long-lasting impacts on human capital formation.

Appendix A

From a One-Tier to a Two-Tier University System: Evidence from the Bologna Reform in Germany

A.1 Standard Study Duration for Diploma Degrees by Field of Study

To define the standard study duration, I exploit information from framework regulations,[1] which provide unbinding recommendations for the standard study durations of magister and diploma degrees. Based on this information, I define the standard study duration for magister degrees as 9 semesters and for diploma degrees as between 8 and 10 semesters, depending on the subject.

I take the maximum standard study durations proposed by a framework regulation and apply these standard study durations to all subjects in the same subject area if there is no framework regulation available for a certain subject. If there is no framework regulation for a subject area at all, I take the maximum standard study duration of other subject areas in the same field of study. As there is no information on the standard study duration in the field of arts for the old programs, graduates from art studies are excluded from the analysis. The following table provides an overview of the assumed standard study duration.

[1] Framework regulations ("Rahmenordnungen") are published together by the Rectors' Conference of German Universities ("Konferenz der Rektoren und Präsidenten der Hochschulen in der Bundesrepublik Deutschland") and the Conference of Ministers of Education in Germany ("Konferenz der Kultusminister der Länder").

Table A.1: *Standard Study Duration for Diploma Degrees by Field of Study*

Field of Study / Subject Area	**Standard Study Duration**
Linguistic & Cultural Sciences	**9**
Sports	**8**
Business, Economics, & Social Sciences	
Business & Economics	8
Regional Studies, Political and Social Sciences, Social Work, Admin. Science, Business Education, Psychology, Educational Science	9
Mathematics & Natural Sciences	
Pharmacy	8
Mathematics, Business Informatics, Earth Science, Geography	9
Natural Sciences, Informatics, Physics, Astronomy, Chemistry, Biology	10
Agriculture, Forest, & Nutrition Sciences	**9**
Engineering	
Mining, Metallurgy, Surveying	9
Engineering, Business Engineering, Mechanical Engineering, Electrical Engineering, Traffic Engineering, Nautical Science Architecture, Spatial Planning, Civil Engineering	10

Notes: The data are taken from framework regulations ("Rahmenordnungen") published by the Rectors' Conference of German Universities ("Konferenz der Rektoren und Präsidenten der Hochschulen in der Bundesrepublik Deutschland") and the Conference of Ministers of Education in Germany ("Konferenz der Kultusminister der Länder").

A.2 Universities Used in the Empirical Analysis

Bauhaus-Universität Weimar
Freie Universität Berlin
Hafencity Universität Hamburg
Humboldt-Universität Berlin
Karlsruher Institut für Technologie
Katholische Universität Eichstätt-Ingostadt
Ludwig-Maximilians-Universität München
Technische Hochschule Aachen
Technische Universität Bergakademie Freiberg
Technische Universität Berlin
Technische Universität Braunschweig
Technische Universität Chemnitz
Technische Universität Clausthal
Technische Universität Cottbus
Technische Universität Darmstadt
Technische Universität Dortmund
Technische Universität Dresden
Technische Universität Hamburg-Harburg
Technische Universität Illmenau
Technische Universität Kaiserslautern
Technische Universität München
Universität Augsburg
Universität Bamberg
Universität Bayreuth
Universität Bielefeld
Universität Bochum
Universität Bonn
Universität Bremen
Universität Duisburg - Essen
Universität Düsseldorf
Universität Erfurt
Universität Erlangen-Nürnberg
Universität Flensburg
Universität Frankfurt am Main
Universität Freiburg im Breisgau
Universität Giessen
Universität Göttingen
Universität Greifswald
Universität Halle
Universität Hamburg
Universität Hannover
Universität Heidelberg
Universität Hildesheim
Universität Hohenheim
Universität Jena
Universität Kassel
Universität Kiel
Universität Koblenz-Landau
Universität Köln
Universität Konstanz
Universität Leipzig
Universität Lübeck
Universität Lüneburg
Universität Magdeburg
Universität Mainz
Universität Mannheim
Universität Marburg
Universität Münster
Universität Oldenburg
Universität Osnabrück
Universität Paderborn
Universität Passau
Universität Potsdam
Universität Regensburg
Universität Rostock
Universität Saarbrücken
Universität Siegen
Universität Stuttgart
Universität Trier
Universität Tübingen
Universität Ulm
Universität Vechta
Universität Würzburg
Universität Wuppertal

A.3 Bologna Reform and Educational Outcomes: Robustness

Table A.3: *Bologna Reform and Final Grades: Robustness*

Dependent:	Final Grade			
	(1)	(2)	(3)	(4)
Bachelor's	37.76***	37.17***	38.22***	37.45***
	(2.009)	(1.899)	(1.946)	(1.240)
Master's	-14.33***	-14.77***	-13.67***	-14.62***
	(1.816)	(1.694)	(1.704)	(1.138)
Female	-6.849***	-6.820***	-6.560***	1.246***
	(0.757)	(1.036)	(1.039)	(0.282)
Student Controls[1]	YES	YES	YES	YES
State of HZB FE[2]	YES	—	YES	YES
Year of HZB FE[2]	YES	—	YES	YES
State-Year of HZB FE[2]	—	YES	—	—
University FE	YES	YES	—	—
Field of Study FE	YES	YES	—	—
University-Field of Study FE	—	—	YES	—
University-Subject Area FE	—	—	—	YES
Observations	1,513,378	1,513,378	1,513,378	1,513,378
Adjusted R^2	0.142	0.144	0.156	0.246

Notes: The first column is the baseline regression with standard errors clustered on the university level only. The second column includes state-year fixed effects to control for educational reforms on the state level; standard errors are clustered at the university-field of study level. The third column includes university-field of study fixed effects; standard errors are clustered on the university-field of study level. The fourth column includes university-subject area fixed effects, and standard errors are clustered on the university-subject area level. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"). Significance levels: *** 1%, ** 5%, * 10%.

[1]Student controls include enrollment age, double degree, and nationality fixed effects.

[2]HZB ("Abitur/Hochschulzugangsberechtigung") is the German university entrance qualification.

Table A.4: *Bologna Reform and Graduation Within Standard Study Durations: Robustness*

Dependent:	Graduation Within Std.			
	(1)	(2)	(3)	(4)
Bachelor's	0.228***	0.230***	0.232***	0.229***
	(0.015)	(0.013)	(0.013)	(0.010)
Master's	0.168***	0.172***	0.170***	0.164***
	(0.013)	(0.012)	(0.012)	(0.010)
Female	0.033***	0.033***	0.032***	0.016***
	(0.003)	(0.003)	(0.003)	(0.001)
Student Controls[1]	YES	YES	YES	YES
State of HZB FE[2]	YES	—	YES	YES
Year of HZB FE[2]	YES	—	YES	YES
State-Year of HZB FE[2]	—	YES	—	—
University FE	YES	YES	—	—
Field of Study FE	YES	YES	—	—
University-Field of Study FE	—	—	YES	—
University-Subject Area FE	—	—	—	YES
Observations	1,542,878	1,542,878	1,542,878	1,542,878
Adjusted R^2	0.155	0.157	0.164	0.190

Notes: The first column is the baseline regression with standard errors clustered on the university level only. The second column includes state-year fixed effects to control for educational reforms on the state level; standard errors are clustered at the university-field of study level. The third column includes university-field of study fixed effects; standard errors are clustered on the university-field of study level. The fourth column includes university-subject area fixed effects, and standard errors are clustered on the university-subject area level. Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), and the data for the calculation of graduation within standard study durations are from the Rectors' Conference of German Universities ("Hochschulrektorenkonferenz"). Significance levels: *** 1%, ** 5%, * 10%.

[1]Student controls include enrollment age, double degree, and nationality fixed effects.

[2]HZB ("Abitur/Hochschulzugangsberechtigung") is the German university entrance qualification.

Appendix B

The Effect of University Rankings on the University Choice of Master's Students

B.1 German Excellence Initiative

The Excellence Initiative was established in 2005, under which the federal and state governments provided funding of a total 1.9 billion euros for the first project phase (2005–2012) and an additional 2.7 billion euros for the second phase (2012–2017). In the course of three rounds (2005/2006, 2006/2007, and 2011/2012), German universities could compete for research funding in three different areas: First, funding for "graduate schools"; second, funding for "clusters of excellence" (= interdisciplinary research clusters); and third, the most prestigious component, funding for "future concepts/institutional strategies." Universities with successful "institutional strategies" could call themselves a "university of excellence" (Deutsche Forschungsgemeinschaft, 2013).

Table B.1: *German Excellence Initiative: Elite University Status*

University	**Round 1 2006**	**Round 2 2007**	**Round 3 2012**
Ludwig-Maximilians-University Munich	x		x
Technical University Munich	x		x
University of Karlsruhe	x		
RWTH Aachen University		x	x
FU Berlin		x	x
Heidelberg University		x	x
University of Konstanz		x	x
University of Freiburg		x	
University of Göttingen		x	
HU Berlin			x
University of Bremen			x
University of Cologne			x
Dresden University of Technology			x

Notes: The data are taken from the German Research Foundation ("Deutsche Forschungsgemeinschaft" (DFG)).

Appendix C

Local Labor Market Conditions and Field of Study Choice

C.1 Local Labor Markets and Initial STEM Choice: Robustness

Table C.1: *Local Labor Markets and Initial STEM Choice: Robustness*

Dependent:	**Log(Share ...) Initial Choice**								
	STEM								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Unemployment	0.009***								
	(0.003)								
Unemployment (Lag)		0.006*							
		(0.004)							
Unemployment (Lead)			0.010***						
			(0.004)						
Unemployment change				0.013***					
				(0.004)					
Unemployment (3 yr. avg.)					0.013***				
					(0.005)				
Unemployment (5 yr. avg.)						0.019***			
						(0.006)			
GDP p.c.							-0.003*		
							(0.001)		
Income p.c.								-0.014	
								(0.014)	
Unemployment (State)									0.017***
									(0.004)
Mean Dep.	33.467	33.467	33.467	33.467	33.467	33.467	33.467	33.467	33.090
Region/state FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	1,387	1,291	1,408	1,291	1,291	1,195	1,387	1,387	240
Adj R2	0.694	0.697	0.692	0.700	0.706	0.732	0.688	0.689	0.833

Notes: Student data are taken from the German Student and Examination Statistics ("Statistik der Studierenden und Statistik der Prüfungen"), the data on business cycle conditions from the Regional Database Germany ("Regionaldatenbank Deutschland"). Standard errors clustered on the regional level are reported in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

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