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To my Family and dear Friends

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Abstract

This thesis studies some of the recent developments within the German education system. The aim is to provide an orientation with respect to the effectiveness and appropriateness of the institutional setting within today's education system. My main interest for the analyses is to evaluate how the institutional setting affects educational chances and choices. The studies focus on the two fringes of formal education: early and higher education. With respect to early education, this thesis studies how school entrance screenings affect the individual and the class composition of competencies at school entry. My research on higher education evaluates recent changes in the higher education sector. First, the implementation of the Bachelor degrees in Germany is studied in order to show whether the restructuring of degrees affected the number of matriculated students and drop-outs. Second, I assess the influence of multidimensional university rankings and an excellence competition on the application behavior of prospective students. Third, I analyze a reform decentralizing university admission to law schools with respect to the efficiency and quality of student-university matching within centralized and decentralized university admission procedures.

Keywords: economics of education, early education, higher education

Zusammenfassung

In dieser Dissertation werden einige der jüngsten Entwicklungen innerhalb des deutschen Bildungssystems betrachtet. Ziel der Analysen ist, institutionelle Regelungen des Bildungssystems genauer zu betrachten und bezüglich ihrer Effektivität und Adäquanz zu bewerten. Dabei liegt das Hauptaugenmerk darauf, wie institutionelle Rahmenbedingungen die Bildungschancen und -entscheidungen beeinflussen. Es werden beide Ränder der formalen Bildung betrachtet: die Elementar- als auch die Hochschulbildung. Im Bereich der Elementarbildung wird analysiert, inwiefern Einschulungsuntersuchungen die Komposition von Kompetenzen innerhalb einer Schuleingangskohorte beeinflussen. Meine Forschung im Hochschulbereich umfasst die Evaluierung einiger der erst kürzlich umgesetzten Reformen. Ich untersuche erstens die Implementierung der Bachelor Abschlüsse und die damit zusammenhängende Entwicklung der Studienanfänger- und Studienabbrecherzahlen. Zweitens ermittele ich den Einfluss von multidimensionalen Universitätsrankings sowie der Exzellenzinitiative auf die Wahl der Universität leistungsstarker Abiturienten. Und drittens nutze ich die Dezentralisierung der Studienplatzvergabe als natürliches Experiment, um die Matching Effizienz und Qualität des zentralen und dezentralen Vergabeverfahrens miteinander zu vergleichen.

Schlagworte: Bildungsökonomik, Elementarbildung, Hochschulforschung

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1 Introduction

The beginnings of formal education date back to the ancient times of the Greek and Roman Empires. The first complete system of compulsory schooling, however, was not introduced until 1559. At that time, the German state of Württemberg implemented a system consisting of three different schools: elementary schools, Latin schools and universities. After John Amos Comenius disseminated his ideas for a system of universal education throughout Europe in the 17th century, it was then the state of Prussia and its minister of education, Wilhelm von Humboldt, who introduced today's scientific and humanistic philosophy of education (Cubberley, 1920).

The German education system of today is constituted in the "Grundgesetz" of 1949 and is decentrally governed by the 16 German federal states. Within the last approximately 60 years, the system of education experienced several times of intense reform debates. Starting with the "Sputnik Crisis" of 1957, the Western nations extensively debated weaknesses of their educational systems as the Sovjet Union demonstrated its predominance in the field of astronautics. The U.S. as well as European states initiated programs to promote and modernize education. In the 1970's, a major topic of debate was the concept of the "Gesamtschule", which was suggested to replace the traditional tracking of students by performance to guarantee equality of opportunities (Führ, 1997).

This aspect of social justice and equality reappeared in the late 1990's after the results of international standardized competence tests indicated substantial performance heterogeneity within the German education system (TIMMS, 1997; PISA, 2000). The internationalization in general and the comparative competence tests in particular increased the comparability of different educational systems with respect to their efficiency and fairness. The international comparability in turn enhanced the eagerness to reform the institutional setting within the education system. For instance, the importance of early education received new attention. As other countries start formal education earlier and as recent research supports the importance of the first years in life for education (Cunha and Heckman, 2007), the pre-school education has been expanded within Germany. Furthermore, the enlargement of the European Union led to major reforms also within the higher education sector. The Bologna Process, initiated in 1999, aims at constructing a homogenous European Higher Education Sector with comparable tertiary degrees all over Europe. Consequently, many European countries – including Germany – restructured their systems of higher education towards the Anglo-Saxon system of Bachelor and Master degrees.

From an economist point of view, it is important to ask which objectives an education system should serve. The intention to increase human capital production and thereby the well-being of a nation is probably the most important goal and seems to be consensus. More controversially discussed is the objective of equal opportunities within the framework of social justice. However, even more difficult is the search for the optimal design of an education system to achieve the agreed-upon objectives. Taking into account that investments in education are constrained by limited financial resources, there are important decisions to be taken. At which age is it especially important to invest in education? Is it the best for children to enter school as early as possible? Should all children be instructed together or is a tracking system based on performance more effective? How do we allocate scarce and expensive university places efficiently?

This thesis studies some of the recent developments within the German education system at the beginning of the 21st century. The aim is to provide an orientation with respect to the effectiveness and appropriateness of the institutional setting within today's education system. My main interest for the analyses is to evaluate how the institutional setting affects educational chances and choices. This is of importance when it comes to suggesting possibilities to improve the future design of the education system. My analyses focus on the two fringes of formal education: early and higher education. With respect to early education, this thesis studies how school entrance screenings affect the individual and class composition of competencies at school entry. My research on higher education evaluates recent changes in the higher education sector. First, the implementation of the Bachelor degrees in Germany is studied in order to show whether the restructuring of degrees affected the number of matriculated students and drop-outs. Second, I assess the influence of multidimensional university rankings and an excellence competition on the application behavior of prospective students. Third, I analyze a reform decentralizing university admission to law schools with respect to the efficiency and quality of student-university matching within centralized and decentralized university admission procedures.

Furthermore, my thesis contributes to the research of education by exploring new administrative data sets. The analyses with respect to the school entrance screenings are carried out using the administrative data of the Brandenburg health authority which is responsible for screening all children prior to school entry within the German federal state of Brandenburg. A similar data set so far has only been used by one other study within the field of economics of education (Salm and Schunk, 2011). For my studies of the recent reforms within the higher education system, I apply two different large administrative data sources. First, I use the administrative student data provided by the statistical offices of Germany which comprises all students at German higher education institutes. Being one of the first researchers employing this data set, data validation showed that the quality and validity can be further improved. However, the most important improvement could be achieved by providing an individual identifier to construct a longitudinal data set. Second, process data of the German central clearinghouse, which allocates students to universities, were exploited. This data set provides high data quality and is very comprehensive as it is, in fact, the data base used by the clearinghouse to match students and universities. Due to the data originating from the internal procedures of the clearinghouse, the data also needs a lot of formatting for the purpose of research. Therefore, it would be very interesting to think of a scientific-use-file along the introduction of new admission procedures for the central clearinghouse.

Chapter 2 of this thesis studies how differences in age and development influence a child's probability of being recommended for school and assesses whether developmental gaps close by delaying school entry. Recent literature shows that fixed cutoff dates regulating school entry create disadvantages for children who are young relative to their classmates (Angrist and Krueger, 1991; Mühlenweg and Puhani, 2010). Early and late school enrollment, though, might mitigate these disadvantages. As a compulsory health examination and in order to assure a minimum developmental level for school start, all German federal states rely on medical screenings of the school entering cohort. The responsible government pediatricians thoroughly examine the health status of the children and perform tests on pre-academic skills such as cognitive development, social behavior or motor skills. At the end of the examination, the pediatrician decides whether to recommend the child to start compulsory primary schooling.

The results show that impairments in cognitive, socio-emotional and motor development as well as health are negatively related to the probability to receive a school recommendation. Moreover, younger children are less likely to be recommended for school. This occurs for two reasons: first, they show developmental impairments more often; second, they have a lower probability of being recommended per se. Delaying school entry allows children to improve, although their developmental status remains below average. Especially children who are still fairly young when being retained catch up during a one-year delay of school entry. This study of my thesis thus shows that flexible school entry rules which – besides age – also take childrens' development into account could mitigate disadvantages for relatively young children.

Chapter 3 discusses the introduction of Bachelor degrees within the German higher education sector in the course of the Bologna Process. For this purpose, short-term effects of the implementation of the Bachelor degree on student enrollment and drop-out rates are estimated at the level of university departments. The main component of the reform is the replacement of the traditional higher education degrees with a homogeneous Bachelor-Master system. The idea was that the comparability of higher education degrees should improve student and labor force mobility, generate competition between universities, and thus increase international competitiveness of the European system of higher education. In some countries – Germany being one of them – an additional political objective was to increase the number of higher education graduates and thereby to address the lack of highly skilled personnel. Compared to the traditional degrees, the Bachelor degree can be obtained in a shorter period of time and is therefore less costly. This could encourage more students to invest in higher education and to finish their degrees. On the contrary, the returns to the new degrees are still uncertain. It is therefore unclear whether the reform has an effect on college enrollment and drop-out rates.

The estimation strategy exploits differences in the timing of the implementation of the Bachelor degrees at the university department level to identify the effects of the reform. The analyses reveal that the introduction of the Bachelor degree has no significant impact on enrollment or drop-out rates for most subjects. However, enrollment to the subjects of electrical, mechanical and industrial engineering as well as to physics is significantly negatively affected by the Bachelor introduction. This result might be interpreted as a sign of students avoiding the new degrees in these subjects because the traditional German engineering degrees have a very good reputation. If this is the case, the observed negative effect should eventually vanish as the traditional degrees are increasingly replaced by Bachelor programs. Hence, we should keep in mind that the effects of the reform on the number of first-year students as well as on drop-out rates may be different in the long-run, when all departments will have implemented the reform.

The analyses of **Chapter 4** shed light on the importance of university rankings for choosing a university. It is analyzed whether prospective high-ability students use ranking indicators as a source of information within the application process and whether the influence of the indicators differs with respect to various quality dimensions – e.g. research quality, mentoring, faculty infrastructure, student assessment and excellence status. Every year, secondary school graduates who want to pursue higher education have to decide which university they want to apply to. This is a crucial decision for their future trajectories made under imperfect information regarding their own ability, university quality and the corresponding returns to a degree. Therefore, quality indicators like university rankings and an excellence competition may provide valuable information for the process of choosing a university.

As identification relies on the variation in ranking indicators and excellence status over time, I can disentangle the effect of the additional information provided by the rankings from the common knowledge regarding university quality. The evaluation shows that the share of applicants increased on average by 19 % at the universities which have received excellence status. Furthermore, the non-research dimensions students-staff ratio, equipment and infrastructure, and the satisfaction of current students rather than the research-related indicators influence university choice of high-ability students. In general, this chapter shows that university rankings are important if they add new information to the common knowledge on university quality.

Chapter 5 addresses the question of whether a centralized or a decentralized university admission procedure is better suited to match prospective students to universities. Prospective students in the U.S. as well as graduate students in the UK need to apply directly at their preferred universities. All undergraduate students in the UK, however, need to apply with the central authority "UCAS" (Universities & Colleges Admission Service) and merely indicate a preference list of universities. In Germany, the central clearinghouse ('ZVS') allocates students to universities in those subjects which exhibit a shortage of university places. Within the field of law studies, the centralized admission procedure was replaced by a decentralized procedure in 2002.

To compare the centralized and decentralized student-university matching, the decentralization of university admission in the field of law is examined as a natural experiment. Using a differences-in-differences strategy, the outcome variables measuring matching efficiency and matching quality are (i) the number of first-year students, (ii) the number of unassigned university places, and (iii) the drop-out rate. The results of my study show that the number of first-year students increased and the number of unassigned places decreased after the decentralization. This increase in the matching efficiency is mainly driven by enabling law schools to abolish all admission restrictions. My estimates with respect to the drop-out rates are not significantly affected by the decentralization. Nevertheless, a comparison between the effects for all treated law schools and for the subgroup of law schools which have always applied admission restrictions suggests that abolishing admission restrictions could be associated with increasing drop-out rates.

Chapter 6 concludes and suggests some ideas for future research.

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2 School Entrance Recommendation: A Question of Age or Development? *

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Abstract

Fixed cutoff dates regulating school entry create disadvantages for children who are young relative to their classmates. Early and late school enrollment, though, might mitigate these disadvantages. In this paper, we analyze in a first step which factors determine school entry if entrance screenings allow for early and late enrollment. Second, we study whether children benefit from a delayed school entry. Using data on a compulsory school entrance screening of a German federal state, we show that children with impairments in cognitive, socio-emotional, motor and health development but also young children are less likely to be recommended to start school. Delaying school entry allows the delayed children to improve, although their developmental status remains below average. School entrance screenings, thus, induce more flexible school entry rules that attenuate performance differences within a class and, as a result, mitigate disadvantages for children being young compared to their classmates.

Keywords: Child development, school entrance, school entrance recommendation

JEL: J13, I21, I38

2.1 Introduction

It has been documented across many countries that children born in the summer months on average perform worse than otherwise identical children. These age effects have been found with respect to various school and labor market outcomes (e.g. Bedard and Dhuey, 2006; Elder and Lubotsky, 2009; Mühlenweg and Puhani, 2010). They are induced by birthday cutoff dates determining a child's school entry age, which are usually fixed in fall. Hence, children born in the summer months are younger when starting school, younger when taking important tests, and they are always the youngest in class. Complying with the fixed cutoff dates, thus, creates disadvantages for children born in the summer months. As a consequence, some studies have suggested more flexible school entry regulations that besides a child's age also take factors like child development into account (Strom, 2004; Jürges and Schneider, 2007).

Although most countries formally rely on fixed cutoff rules to regulate school entry, other factors besides age are also sometimes considered for the decision to enter school. In the U.S. for example, children are supposed to start compulsory schooling with kindergarten at the age of five. In some states, however, the children may need to go through a school readiness test or may be interviewed by the school principal before entering school. The final decision about school entry is taken by the parents, and therefore, some children are retained and thus deviate from the fixed cutoff rule.

Deviations from the cutoffs also occur in Germany. Schooling in Germany starts one year later with the entrance into primary school at the age of six. In contrast to the U.S., compulsory standardized medical screenings are carried out in all federal states prior to school enrollment. A government pediatrician thoroughly examines the health status of the children and performs tests on pre-academic skills such as cognitive development, social behavior or motor skills. At the end, the pediatrician decides whether to recommend the child to start compulsory primary schooling or to delay school entry. Depending on the school law of the particular state, either the parents or the school principal ultimately decides on school entry taking the pediatrician's decision into account. Such developmental school entrance screenings, thus, also reduce compliance with strict age-based school entry rules and allow for a more flexible school entry.

The question that arises from these observations is whether such standardized school entrance screenings indeed mitigate the disadvantages for children born in the summer. Therefore, we study the following two aspects. First, if it is not (only) age that determines school entry, which other factors drive a child's probability to be recommended for school? And does deviating from strict cutoff rules yield developmentally more homogeneous school cohorts? Second, as some children are retained from schooling due to the screening, it is important to ask wether the selective group of retained children benefits from delaying school entry. This paper addresses these two aspects by analyzing how early differences in age and development influence a child's probability to be recommended for school and whether developmental gaps close over a one-year delay. For our study, we use a novel and unique administrative data set on the school entrance screening of all children in the school entrance cohorts 2006 and 2007 living in the German federal state of Brandenburg.

Regarding our first research question, the recent school entrance literature indirectly hints at the fact that age effects are smaller when non-compliance with the fixed cutoff rules is observed. Starting with the seminal paper by Angrist and Krueger (1991), the recent literature on school entrance age identifies the causal effect of absolute and relative age gaps on child outcomes using school entry cutoff dates in an Instrumental Variable (IV) approach. Many studies followed this identification strategy analyzing the effect of absolute and relative age on school outcomes (Strom, 2004;

Bedard and Dhuey, 2006; Datar, 2006; Elder and Lubotsky, 2009; Crawford et al., 2010; Robertson, 2011), on tracking (Allen and Barnsley, 1993; Puhani and Weber, 2007; Mühlenweg and Puhani, 2010) and on labor market outcomes (Fredriksson and Öckert, 2006; Black et al., 2008; Dobkin and Ferreira, 2010). Predominantly, these studies find that children who are young relative to their classmates perform worse.

The IV estimates of the causal effect of age on performance represents differences between young and old children that comply with the fixed cutoff dates. Bedard and Dhuey (2006) and Jürges and Schneider (2007) compare the IV estimates of the age effect to the results of Ordinary Least Squares (OLS) regressions. In all countries studied, the OLS estimates suggest smaller disadvantages for young children than the IV effects. Both studies attribute the difference between IV and OLS results to early and late enrollment as well as to grade retention, i.e. non-compliance with the fixed cutoff dates. Thus, non-compliance with fixed cutoff rules, e.g. by considering more factors than only a child's age, seems to reduce performance heterogeneity in the classroom. Despite its importance for the identification of age effects, little is known about the determinants of early and late school enrollment and whether a school entrance screening yields developmentally more homogenous classes.

Regarding the second question, evidence with respect to grade retention is extensive. However, the majority of the existing studies analyzes grade retention in primary school or later, e.g. third grade in primary school or sixth grade in high school (Jacob and Lefgren, 2004; Greene and Winters, 2007). Using regression discontinuity designs, these studies find small but positive effects on the retained students in primary school. Examining the effect on all students, not only on the retained, and exploiting state-level differences in retention rates, Babcock and Bedard (2011) find a positive effect of grade retention in primary school on hourly wages. The results on kindergarten retention point in a similar direction. The most recent study by Dong (2010) analyzes early grade retention in kindergarten and finds a positive but diminishing effect when accounting for the selection in retained students. As the literature on grade retention focuses on the causal effect of retaining, it shows how the retained children perform compared to their enrolled counterparts. However, little is known about how retained children compare to their now younger peers.

Our paper complements the literature by analyzing how early differences in age and development influence a child's probability to be recommended for school. Although the recommendation is not formally binding, parents and school principal usually follow the pediatrician's advice. Using the school recommendation as a proxy for school entry, we provide first evidence regarding the determinants of early and late school enrollment. Furthermore, we add to the scarce literature on early grade retention and delayed school entry. This is important as the decision on school entry age and whether children catch up during a one-year delay determines the extent to which developmental and performance gaps in fact exist in a classroom and, thus, whether school entrance screenings can mitigate disadvantages for summer-born children caused by fixed cutoff rules.

The analyses benefit from a very rich and novel administrative data set. As the screening is mandatory for all children living in the German federal state of Brandenburg, we observe all children who reach school age in the years 2006 and 2007, i.e. about 22,000 observations each year. Only children with severe physical and mental disabilities may be exempted from the examination. Furthermore, we can observe the children who delayed school entry twice – at the initial screening in 2006 and when repeating the screening in 2007. Due to a missing panel identifier, we employ propensity score matching to identify the first nearest neighbors for the non-recommended children of 2006 within the group of repeating children of 2007. The nearest neighbor is ideally the same child. The matching allows us to study whether children catch up by delaying school entry. To our knowledge, only one other economic study uses data of a school entrance examination and analyzes the impact of health on cognitive and language abilities (Salm and Schunk, 2008). But similar to most epidemiological studies, the authors rely on data from a local health authority and thus on a much smaller data set.

Our results show that developmental status and also age are important predictors for the pediatrician's school recommendation. Impairments in cognitive, socio-emotional and motor development as well as health are negatively related to the probability to receive a school recommendation. Moreover, younger children are less likely to be recommended for school even if developmental status is controlled for. This result is of particular importance to the children who are born in months close to the cutoff month. As they are the youngest, they are systematically more likely to be held back for one year.

Regarding the second question, delaying school entry allows children to improve although their developmental status remains below average. Especially children who are still fairly young when being retained catch up during a one-year delay of school entry. This might be easier for them as a smaller fraction of non-recommended younger children shows developmental impairments in the first place. Pediatricians might either anticipate the improvement of younger children or might want to place them into a more favorable age position in the cohort of the following year. In sum, a school entrance screening provides a means to mitigate developmental heterogeneity in a classroom. Thus, standardized examinations can attenuate disadvantages for children born in the summer by introducing more flexible school entry regulations.

The paper is structured as follows. The next section gives some background information on the school entrance screening (Section 2.2). The novel administrative data set is described in Section 2.3, the estimation strategy is presented in Section 2.4, and the interpretation of the results follows in Section 2.5. Section 2.6 concludes.

2.2 Institutional Background

In Germany, children usually start formal schooling with entrance into primary school in the year they turn six years old. Before starting school, all children need to attend a school entrance screening. This is a detailed medical screening, which is mandatory to all children who turn six. Its main purpose is to check on children's health and development as some of the children may not have been presented to their family pediatrician for any preventive voluntary routine check-ups for babies and infants. If the child shows developmental impairments, parents get advice for further medical treatment, and a controlling scheme is implemented. At the end of the examination, the pediatrician also decides whether to recommend the child to start compulsory primary schooling.

In addition to the recommendation, parents in the federal state of Brandenburg may request for their children to delay or start school early. However, the final decision on school entry is up to the school principal taking the pediatrician's recommendation and parents' requests into account.[1] Although the recommendation of the pediatrician is not formally binding, parents and school principal usually follow the recommendation.[2] In general, there is a tendency of the parents to request a delay although their child has been recommended for school than to request an early start without a recommendation of the pediatrician.[3]

[1]For the details of the legislation, consult the school law of Brandenburg (Landtag Brandenburg, 2006).

[2]As shown in Section 2.3, the vast majority of the children (93-94%) who delay school entry have been recommended to do so by a pediatrician. Thus, only very few parents and school principals deviate from the pediatrician's recommendation by retaining children who received a school recommendation.

[3]Our data hints at this as we do observe more children repeating the screening in 2007 than were not recommended in 2006 (see Section 2.4.2).

The screenings take place from January to May each year. They are administered on the county level by government pediatricians according to standards set by the ministry of health in Brandenburg. All indicators and the sub-tests used are described in a handbook, which is available to all government pediatricians who administer the screenings (Landesgesundheitsamt Brandenburg, 2008). The screenings comprise a complete medical assessment of the child and a questionnaire answered by the parents. The medical assessment covers the body health status of the children, tests on cognitive and socio-emotional development as well as on motor skills. In the questionnaire, parents give some information on home and family environment by answering questions on parental education, their labor market participation, immigration background and the child's behavior at home and in kindergarten.[4]

Cognitive development is measured using an articulation test and a grammar test for expressive language. Children who show a disorder of speech and language according to the articulation and the grammar test are further tested with respect to receptive language disorders and general intelligence. The general intelligence test is a nonverbal test and is especially developed for children who showed difficulties with speech and language. Psychiatric disorders in socio-emotional development are screened using questions from a structured interview with the parents. The assessment includes measures for anxiety, anti-social (i.e. aggressive) behavior, attention deficit hyperactivity disorder (ADHD) and enuresis.[5] Tests on motor development include measures for gross motor skills to examine physical strength, coordination as well as dynamic and static balance. Tests used include standing and jumping on one leg as well as walking in a straight line using tandem gait (heel-to-toe-walking).[6] The body health

[4]The examinations are based on a core set of indicators of the International Classification of Functioning, Disability and Health (ICF) developed by the World Health Organization (Üstün et al., 2003; Simeonsson et al., 2003). See the Appendix for details on the sub-tests and the parental questionnaire.

[5]The questions used for diagnosis are displayed in Figure A.2.1 in the Appendix.

[6]The development of motor functions is important for the overall development of perception and cognition. Although there seems to be no systematic relationship to later school performance (Blomeyer

screening is very comprehensive and includes the domains height, weight, Body Mass Index (BMI), allergies and asthma, musculoskeletal system, endocrine system, hearing and seeing as well as the skin.

2.3 Data

Our data include all children participating in the school entrance screenings in Brandenburg in the years 2006 and 2007.[7] As participation in the screening is mandatory for all children of a cohort, the results can serve as a representative overview on the status of the population of school starters in the state of Brandenburg in the respective year.[8] The legal cutoff date for starting school in this state is September 30th each year.

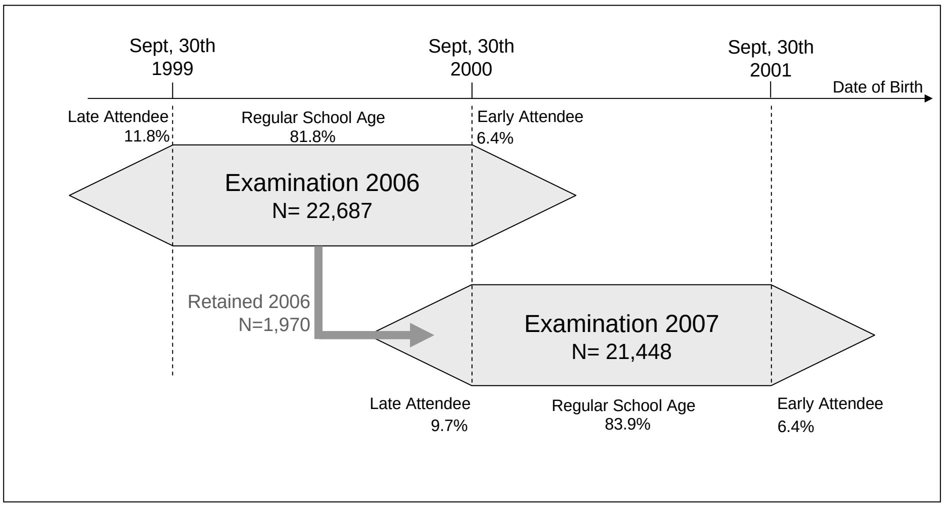
Figure 2.1 explains the structure of our data. Children who turn six by the end of September 2006 (September 2007) have to attend the school entrance examination in 2006 (2007). The children who need to attend the school entrance screening in 2006 are born between October 1st, 1999 and September 30th, 2000. Analogously, children attending the screening in the following year, i.e. 2007, are born between October 1st, 2000 and September 30th, 2001. For the year 2006, we have data on 22,755 children who attend the school entrance screening. We have to drop 68 observations (0.3%) because information on the school recommendation or the date of birth are missing. In the following year, 21,504 children attended the examination, and 56 (0.3%) were

et al., 2009), motor skill problems and poor performance in physical education might put these children at a higher risk of being bullied (Bejerot and Humble, 2007; Bejerot et al., 2011).

[7]Researchers may request access to the data by applying at the Landesgesundheitsamt Brandenburg, Dr. Gabriele Ellsaesser, Wuensdorfer Platz 3, D-15806 Zossen. The authors are willing to advise others about access to the data and the application process.

[8]As responsibility for education is on the federal state level in Germany, no nationwide standardized testing procedures for school entrance screenings exist. Moreover, the screenings are administered at the county level, so comparable data and comprehensive reports on the federal state level are scarce.

Figure 2.1: Structure of School Entrance Cohorts

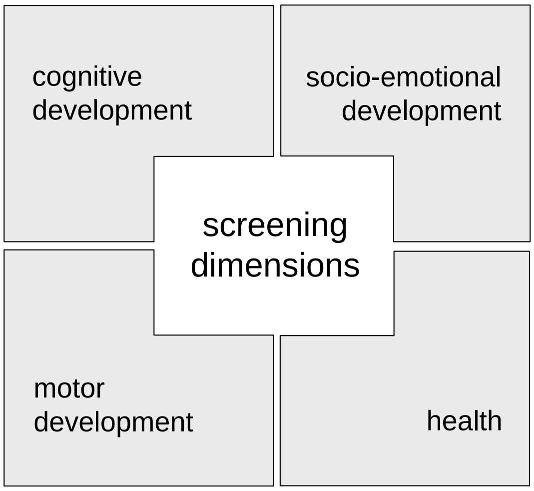


Data Source: Health Ministry of Brandenburg 2006, own calculations.

dropped because of missing information on the same variables. Our estimation sample thus consists of 22,687 observations for 2006 and 21,448 observations in 2007.

For children born after September 30th – especially if they are born before the end of December – parents can request for their child to attend the school entrance screening a year early. We refer to these children as “early attendees”. This applies to about 6.4% of all children in both years. Note that “early attendees” are a positively selected group of children due to this procedure. In contrast, some children in our samples are above compulsory school entry and attend the screening for a second time. This is the case for 11.8% of the children in 2006 and 9.7% in 2007. Most of these “late attendees” (93% in 2006, 94% in 2007) were not recommended the year before and attend the entrance screening a second time. Thus, they represent a negatively selected group which was retained from an earlier school entry. 1,970 children were retained in 2006 and examined a second time in 2007. We use this sample of children for our analysis on the development of retained children presented in Sections 2.4.2 and 2.5.2. Note that our data unfortunately do not contain any panel identifier. Therefore, we use

Figure 2.2: Screening Dimensions



Data Source: Health Ministry of Brandenburg 2006.

a matching procedure to identify the non-recommended children of 2006 within the group of children who repeat the screening in 2007.

The developmental status is assessed in four screening dimensions: cognitive abilities, socio-emotional wellbeing, motor skills and health (see Figure 2.2). As these indicators are not measured on continuous scales, we use binary variables for each of the dimensions which indicate whether a child shows developmental impairments in this dimension or not. All indicators in the four dimensions depend on several sub-tests and on the clinical judgment of the physician.[9]

The school entrance recommendation of the pediatrician is a condensed assessment given based on the pediatrician's own observations, a questionnaire completed by the parents and the results of the standardized assessments for developmental status and health. Unfortunately, we neither observe whether parents request a delay of school

[9]The pediatricians are given detailed and comprehensive information on all parts of the examination in a handbook. This is constantly updated, and regular quality meetings are held to reinforce the standards set by the ministry of health in Brandenburg. Although most pediatricians commit to these standards, the data show that not all of them deduce their diagnosis from the sub-tests. We therefore consider both subtests and the pediatrician's judgement to classify developmental impairments. See Section 2.2 and the Appendix for details on the sub-tests.

start although their child has been recommended nor whether they request for their child to start school without a recommendation. As the final decision of the school principals is not available in the data either, we do not know whether a child in fact delays school entry. Hence, our analysis uses the pediatrician's decision as a proxy for actual school entry. This is justifiable as we have shown before that deviations from the pediatrician's decision are not very common.

2.4 Estimation Strategy

To assess the importance of school entrance screenings for detecting and mitigating early performance differences, we are interested in two questions. First, which factors influence a child's probability to be recommended for school, and second, do developmentally gaps close by delaying school entry? In the following, we explain the estimation strategies to answer these questions.

2.4.1 Determinants of School Entrance Recommendation

To answer the first question, we use the school entrance recommendation as dependent variable. The indicator variable Rec_i is 1 if the child i is recommended to start primary school in the year of the examination and 0 otherwise. The underlying estimation equation is displayed in Equation 2.1 and estimated using a probit model.

$$Rec_i^* = \beta_0 + \beta_1 Age_i + \beta_2 DEV_i + \beta_3 C_i + \beta_4 F_i + \beta_5 M_i + u_i \tag{2.1}$$

The main variables of interest are age (Age_i) and a vector of our four developmental status variables (DEV_i). Age is measured in months at the time of the entrance examination. The binary development variables pick up impairments in each of the four domains cognitive development, social behavior, motor skills and health.

Furthermore, we sequentially include interaction terms between the developmental indicators and age separately for each dimension as shown in Equation 2.2. These interactions capture the joint effect of age and development on recommendation and thereby indicate heterogenous effects of the developmental status with respect to age.

$$Rec_i^* = \beta_0 + \beta_1 Age_i + \beta_2 DEV_i + \beta_3 DEV_i \times Age_i + \beta_4 C_i + \beta_5 F_i + \beta_6 M_i + u_i \quad (2.2)$$

Control variables for both equations include a vector of child (C_i) and family (F_i) background variables as well as dummies for the month of examination (M_i). Background information on the child (C_i) include gender, birth weight, non-German mother tongue and attendance of institutional child care. We also include binary variables indicating children below ("early attendees") and above regular school age ("late attendees") as these are positively ("early attendees") or negatively ("late attendees") selected groups. Family background variables (F_i) provided by the parents are parental education, their labor market participation, immigration background, family type and the number of siblings. Parental education and labor market participation are combined into a variable capturing the socio-economic status (SES) for both parents.[10] Dummies for the month of examination (M_i) are included to control for the

[10]We use the SES-classification provided and published by the ministry of health in Brandenburg (Böhm et al., 2007). Parents are classified into high socio-economic status if both have a high-school diploma (more than 10 years of compulsory school education) and at least one of them is full-time employed. In case of missing values or single parenthood, the characteristics of the remaining parent are also assigned to the second parent. We include dummy variables for single parenthood and missing values in our regression. Results do not change when using education and labor market participation of the mother instead of the predefined socio-economic status.

length of the period until school entry.[11] As development of children in this age group might change within a few months, pediatricians could possibly recommend children more "generously" in the early months of the examination period, e.g. January and February, as there is still some time left for improvements until school entrance in September.

2.4.2 Development of Retained Children

To analyze whether the performance differences in school are mitigated by retaining, we exploit the fact that some children repeat the screening. Children who are not recommended to school in 2006 spend an additional year in kindergarten and attend the school entrance screening again in the following year. As early child development is very heterogenous and tightly depends on age, developmental impairments might not be persistent, and children might catch-up. Furthermore, the pediatricians are advised to recommend further treatment to the parents of children who were diagnosed with developmental impairments. Therefore, we expect that retained children improve during the one-year delay.

Unfortunately, the data do not allow the tracking of children over time by a panel identifier. However, using the data of 2006 and 2007, we observe the non-recommended children of 2006 and the repeaters of the examination in 2007. As the school recommendation is not binding, we observe 1,970 non-recommended children in 2006 and 2,316 repeaters in 2007.[12] As we are interested in the development of the non-

[11] The examination is predominantly taken from January to May; however, there are very few children tested in the months June to December. The control variable for month January thus includes also the months October, November, December. The variable for month May includes also the months June, July, August and September. Reference category is March as this is the month where most examinations are taken.

[12] The addition of 346 children is caused by parents who hold back their children although they have been recommended.

recommended children, we restrict the 2007 sample to those repeaters who we most likely already observe in 2006. Subsequently, we compare the development of this adjusted group of repeaters to their developmental status a year earlier.

In order to identify the repeaters in 2007 who were most likely not recommended in 2006, we employ propensity score matching without replacement to match an observation of 2006 to its first nearest neighbor in 2007 (which is ideally the same child) according to its characteristics. We exclude the 346 repeater observations of 2007 which were not identified as nearest neighbors and are thus left with 1,970 non-recommended children in 2006 and 1,970 repeating children in 2007. Resulting from the matching, these groups contain most likely the same children. In the following, we refer to this subsample of repeating children in 2007 as the group of repeaters. The characteristics of the 1,970 non-recommended children in 2006 and the original 2,316 repeaters in 2007 are largely overlapping so that we can assure common support (see Figure A.2.3 in the Appendix). We only match on characteristics of the child and the parents which we expect to be constant over time (gender, birth month and year, birth weight, non-German mother tongue, maternal school education, single parenthood and siblings) and obtain a sample which is largely balanced (see Table A.2.3 in the Appendix for t-tests on the differences in characteristics for retainees and repeaters). Our sample for 2007 contains 21,102 observations after the matching and is thus smaller by the 346 observations which do not have a non-recommended counterpart in 2006. We use this adjusted data set to analyze the development of retained children.

By comparing the probability for developmental impairments at the two examinations the repeating children attend, we can describe the development of the retained children during the one-year school delay. This is done by pooling the matched cross-sections of the examinations in 2006 and 2007. Hence, the data contains all children examined in 2006 and 2007 apart from the 346 repeating children in 2007 who are not a nearest neighbor to a non-recommended child in 2006. In this sample, we define dummy variables indicating that a child was non-recommended in 2006 ($NonRec06_i$) and is a repeater in 2007 ($Repeater07_i$). By that, we can compare the probability of developmental impairments for children at the time they are not recommended with the developmental status of their matched counterparts one-year later. The estimation equation reads as follows:

$$\begin{aligned} DEV_i^* = \beta_0 &+ \beta_1 NonRec06_i + \beta_2 Repeater07_i \\ &+ \beta_3 Repeater06_i + \beta_4 NonRec07_i + \beta_5 Year07 \\ &+ \beta_6 C_i + \beta_7 F_i + \beta_8 M_i + u_i \end{aligned} \tag{2.3}$$

Our binary outcome variables for the four developmental dimensions DEV_i equal one if child i shows an developmental impairment in the according dimension. The indicators for being non-recommended in 2006 ($NonRec06_i$) and a repeater in 2007 ($Repeater07_i$) are our variables of interest we want to compare. To ensure that we always refer to the same group of children as the reference group, we additionally include dummy variables for being a repeater in 2006 ($Repeater06_i$), being non-recommended in 2007 ($NonRec07_i$) and a year dummy for 2007 ($Year07$). Moreover, the same child (C_i), family (F_i) and month of examination (M_i) control variables as in Equation 2.1 are included in the estimation. Hence, the probability of showing a developmental impairment is calculated in reference to non-repeating, recommended children of 2006 with similar child and family characteristics. The average partial effects on the two dummy variables of interest ($NonRec06_i$ and $Repeater07_i$) are calculated only for the children belonging to the group of repeaters, i.e. as average treatment effect on the treated. The difference between the partial effects of the two groups can be interpreted as the reduction in the share of children with developmental impairments, which is achieved by delaying school entry.

2.5 Results

The results of our analysis regarding the two research questions are discussed in the following. In Section 2.5.1, we present the estimation results with respect to the determinants of a school entrance recommendation, and Section 2.5.2 focuses on the retained children and whether they improve with respect to their developmental status by delaying school entry.

2.5.1 Determinants of School Entrance Recommendation

Before estimating the determinants of receiving a recommendation for school, we first compare the mean characteristics of recommended and non-recommended children. At the 2006 examination, 90.5% (20,717) of the children are recommended for school. Table 2.1 shows the differences between the recommended and non-recommended children with regard to child characteristics, developmental impairments and parental background.[13]

The comparison shows that the recommended and non-recommended children differ substantially, especially with regard to the measures of developmental status and health. In the recommended cohort, fewer children show impairments in cognitive, socio-emotional or motor development. Most of the children affected by cognitive impairments are diagnosed with developmental disorders in language, and only very few (2% out of the 11% of the non-recommended children) show deficits in intelligence. Disorders in socio-emotional development comprise anxiety, anti-social (i.e. aggressive) behavior, enuresis and Attention Deficit/Hyperactivity Disorder (ADHD). 3%

[13]For the full sample of 2007, the recommendation rate is 91.1% (19,535 out of 21,448). For the sample of 2007, the analysis of group means yields similar results as for 2006. Some of the variables have a small amount of missing values, see table notes of Table 2.1. The regressions include dummies for missing values.

Table 2.1: Means of Recommended vs. Non-recommended Children in 2006 (%)

	Recommended	Non-recommended
Child		
Female	0.48	0.36
Age (in months)	72.02	67.49
Non-German mother tongue	0.02	0.03
Birth Weight (in kg)	3.39	3.23
Child care > 3 years	0.70	0.49
Early attendee	0.05	0.18
Late attendee	0.13	0.00
Developmental Impairments		
Cognitive development	0.11	0.50
Socio-emotional development	0.08	0.34
Motor development	0.12	0.44
Health	0.39	0.52
Family Background		
Low SES	0.18	0.32
Medium SES	0.55	0.51
High SES	0.26	0.17
Single Parent	0.17	0.21
Siblings	0.66	0.68
N	*20,717*	*1,970*

Data Source: Health Ministry of Brandenburg 2006, own calculations. The number of observations is the total number without considering missings. The following variables have missing values: non-German mother tongue, birth weight, child care, social status, single parent and number of siblings. The maximum share of missing values amounts to 3.9% for the recommended and to 6.7% for the non-recommended children. T-tests on the group means are performed. All differences are significant at the 1% level, except the difference for non-German mother tongue (not significant) and siblings (significant at the 10% level).

of the recommended and 11% of the non-recommended children are diagnosed with ADHD behavior.

The comparison shows further that recommended children are more frequently girls, are older, have had a higher birth weight and longer child care experience. Children above compulsory school age ("late attendees") are always recommended. Children with a low social status are less often recommended to start school. Recommended and non-recommended children do not differ much with regard to the presence of siblings or living in a single-parent household.

The probit model introduced in Equation 2.1 confirms the results of the mean comparison. Table 2.2 reports the results of this regression for different specifications. The marginal effects presented in the table are average partial effects, i.e. we calculated the individual probability for each observation and then averaged over all observations.

The results presented in the first column reveal that there is a substantial positive influence of age. Each month the child is older when attending the screening raises the probability of being recommended for school by 2.0 percentage points. Including the four variables for developmental status in specification (II) shows that they significantly influence the probability to be recommended. Especially cognitive and socio-emotional development seem to be important for school recommendation. Compared to the reference group of mean age children with the same background and without impairments in the four dimensions, showing e.g. cognitive impairments reduces the probability to be recommended to school by 15.6 percentage points. Although slightly decreasing, the age effect persists when controlling for developmental status. Age increases, ceteris paribus, the probability of school recommendation by 1.6 percentage points per month. Thus, an age difference of 12 months would result in a larger impact than showing an impairment in cognitive development. We also

Table 2.2: Probit Regression of School Recommendation on Age, Developmental Status and Interaction Terms (2006)

	Average partial effects					
	(I)	(II)	(III)	(IV)	(V)	(VI)
Age (in months)	0.020***	0.016***	0.016***	0.015***	0.016***	0.016***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Development						
Cognitive		-0.156***	-0.236	-0.158***	-0.156***	-0.156***
		(0.007)	(0.156)	(0.007)	(0.007)	(0.007)
Socio-emotional		-0.102***	-0.102***	-0.871***	-0.102***	-0.102***
		(0.007)	(0.007)	(0.006)	(0.007)	(0.007)
Motor		-0.068***	-0.068***	-0.068***	-0.106	-0.068***
		(0.005)	(0.005)	(0.005)	(0.108)	(0.005)
Health		-0.009***	-0.009***	-0.009***	-0.009***	-0.027
		(0.003)	(0.003)	(0.003)	(0.003)	(0.062)
Interaction terms						
Cognitive × age			0.022***			
			(0.003)			
Soc.-em. × age				0.023***		
				(0.003)		
Motor × age					0.011***	
					(0.002)	
Health × age						0.002*
						(0.001)
Child controls			*yes*			
Family background			*yes*			
Month of examination			*yes*			
Missing dummies			*yes*			
Pseudo$-R^2$	0.2268	0.3778	0.3778	0.3811	0.3778	0.3778
N			*22,687*			

Data Source: Health Ministry of Brandenburg 2006, own calculations. */**/*** indicate significance at the 10/5/1 percent level. Child controls include variables female, non-German mother tongue, birth weight, child care duration longer than 3 years as well as dummies for early and late attendees. Control variables on family background include dummies for socio-economic status, single parenthood and siblings living in the household. The month of examination is controlled for by dummy variables. Missing dummies are included to indicate observations with missing values in one of the variables. Missings are set to zero (dummy variables) or to the mean (continuous variables) and included in the regression. The average partial effects for the control variables are presented in Table A.2.1 in the Appendix.

estimated the age effect including binary variables for different age groups in order to check for non-linearities in age. The estimates suggest an concave age effect, i.e. especially the very young children are less likely to be recommended for school merely due to their age (see Table A.2.2).

Finally, we interact age and developmental status to assess whether age affects children with and without developmental impairments differently (III-VI). The results in the third column show the estimated marginal effects when including the same variables as before and adding an interaction term for cognitive impairment and age.[14] Similar as in specification (II), the age effect for children without an impairment amounts to 1.6 percentage points. Taking the cognitive interaction term into account, we find that the age effect for children with a developmental disorder increases to 3.8 percentage points.[15] Hence, for a child with a cognitive impairment, each month of age raises the probability to be recommended much more than for a child without cognitive impairments. The age effect for a child with a socio-emotional disorder is similar (3.8 percentage points), while age is less important for children with a motor (2.7 percentage points) or health (1.8 percentage points) disorder.

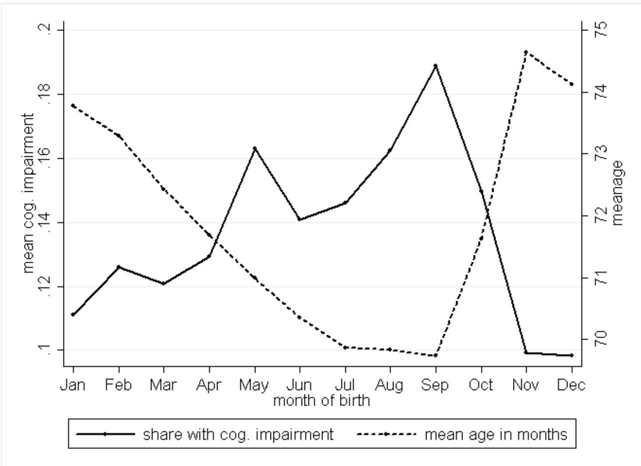
The other socio-economic background and child variables are related to the probability to receive a school recommendation, albeit to a low extent. Average partial effects for the control variables are reported in Table A.2.1 in the Appendix. Being female, birth weight, child care experience and high socio-economic status of the parents are positively related to school recommendation. Furthermore, both early and late attendees are more likely to be recommended for school. For late attendees, this result indicates that not recommending children for school might not be an option

[14]The marginal effects of the interaction terms are computed using the method introduced by Ai and Norton (2003). Effect sizes and significance levels are similar to estimating all interaction effects together in a linear probability model with robust standard errors.

[15]In order to calculate this effect, we need to sum the age effect for children without impairments (1.6 percentage points) and the age effect for children with an impairment as opposed to children without any developmental disorders (2.2 percentage points).

once they are already older than their peers. For early attendees, the positive effect seems plausible as well as they might be a very selective group with characteristics not entirely captured by the parental control variables.[16] The results for the month of examination dummies suggest that children examined earlier in the year have a slightly higher probability to be recommended. The pediatricians may take into account that early tested children still have some months to develop until school starts.

Figure 2.3: Developmental Status and Age by Month of Birth



Data Source: Health Ministry of Brandenburg 2006, own calculations.

The influence of age on the school entrance recommendation is particularly important for those children born close to the cutoff month set by federal state law. Children who are born earlier in their school cohort (e.g. in the fourth quarter of the year) are older when passing the school entrance screening compared to children who are young in their cohort (i.e. born in the third quarter of the year). Figure 2.3 shows the inverse relationship between age (dashed line) and share of children diagnosed

[16]As a robustness check, we estimated the equations on a sample of 18,551 children, excluding early and late attendees. These estimations yield similar results for all covariates, e.g. the age effect is between 1.7 and 1.9 percentage points depending on the specification.

with cognitive impairments (solid line) by month of birth.[17] The age at the school entrance examination is constantly decreasing the closer a child's month of birth is before the school entry cutoff date end of September. As seen, these children have a lower probability of being recommended for school because developmental disorders are more prevalent among the young children and because there is an additional negative impact of being young.

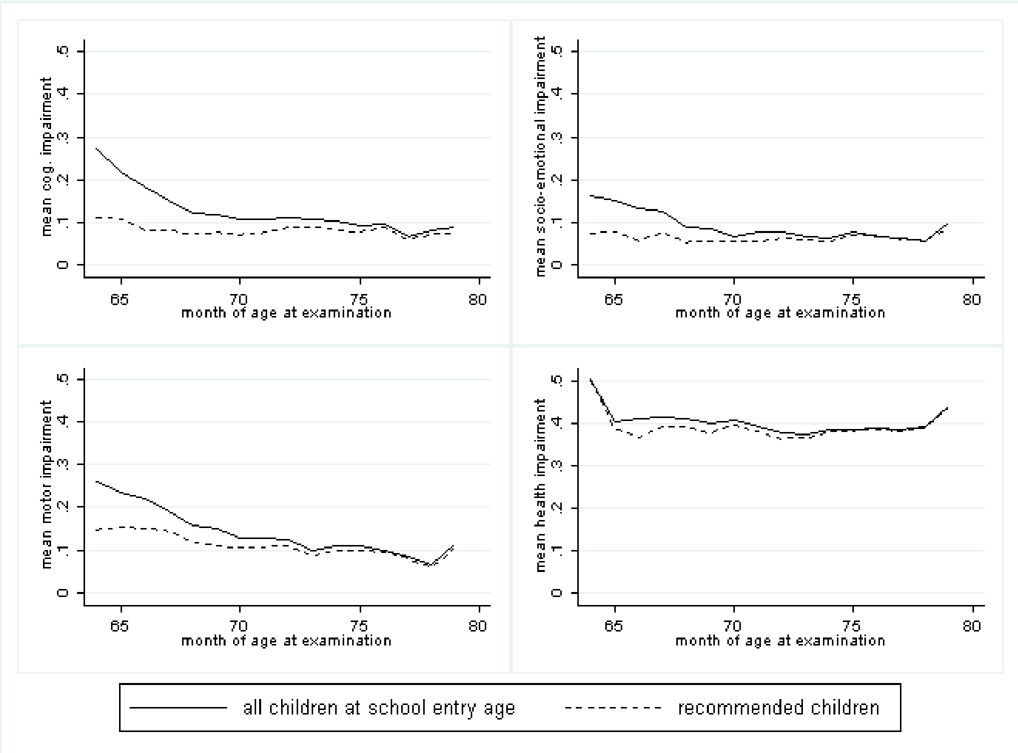
Moreover, comparing the sample of all children at school entry age to the group of recommended children provides evidence that young children with a high share of impairments are less likely to receive a recommendation (Figure 2.4). Here, the solid line indicates the share of children showing an impairment within the group of all children at school entry age, compared to the share within the group of recommended children (dashed line) by age in months at the time of examination. In the full cohort, the share of impairments decreases by age in all four screening dimensions. Within the group of recommended children, the share of cognitive and socio-emotional disorders are almost equally distributed across age. This change in composition is less pronounced for the indicators motor skills and health, which confirms their lower importance for the recommendation.[18] The entrance screening, thus, especially reduces heterogeneity between the children of the school entrance cohort with respect to cognitive and socio-emotional development.

To summarize the results of the first part, recommending children for school based on the results of a developmental screening procedure yields a school cohort with less developmental heterogeneity compared to a pure age-based entry regulation. The

[17]The relationship also pertains for the other developmental indicators (socio-emotional development, motor skills and health).

[18]Most sub-tests also indicate a higher share of impairments for young children. For example, young children in particular show ADHD behavior (Figure A.2.2). However, this should not be misinterpreted as "misdiagnosing" young children with ADHD as the questions inducing an ADHD impairment are quite rudimentary and, thus, only constitute an initial suspicion (see ADHD questions in Figure A.2.1 in the Appendix).

Figure 2.4: Developmental Impairments by Month of Age at Examination (in %)



Data Source: Health Ministry of Brandenburg 2006, own calculations.

estimations show that the pediatricians give their recommendation not only based on the child's development but also take the age of the child into account (see results in Table 2.2). Hence, the screening can be seen as a minimum hurdle which creates a more homogeneous school entry cohort. We show that performance differences in school, as described by the literature on school entry age, can be mitigated by school entrance screenings because better developed and older children are more likely to receive a school recommendation. However, this is only the case if the developmental status of retained children improves during a one-year delay of school entry. This is what we analyze in the next step.

2.5.2 Development of Retained Children

Having information on the school entrance screening in two subsequent years allows us to compare the developmental status and health of the retained children in the first examination in 2006 with the second examination in 2007. In this section, we assess by how much non-recommended children in 2006 deviate from non-repeating, recommended children of 2006 with respect to their development. Then we compare the developmental status of the non-recommended children in 2006 one year later (repeater 2007) to the same reference group and see whether the children's development improved during the one-year delay. In addition, we estimate separate effects for children of different age groups in order to assess whether retaining has heterogenous effects with respect to age.

Table 2.3 shows mean statistics of the repeating children in 2006 and 2007. Additionally, mean differences between non-recommended (repeating respectively) and recommended children in the two years are depicted. Comparing the means between the non-recommended children of 2006 and the repeaters of 2007 shows that child and background variables are similar with exception of the time-varying variables age and time spent in child care, which are larger due to the one-year delay. The values on the developmental status indicate improvements in all four dimensions, e.g. the share of children with cognitive impairments decreases by 17 percentage points, from 50% of the non-recommended children in 2006 to 33% of the repeaters in 2007. Disorders in the health dimension are more persistent. Retained children in this dimension catch up by only 7 percentage points.

The same improvement can be seen when looking at the mean difference to the recommended children as displayed in columns 5 and 6 of Table 2.3. For example, the gap in cognitive impairments of 39 percentage points in 2006 decreases to 20 percentage

Table 2.3: Mean Values for Repeaters and Mean Differences Between Repeaters and Recommended Children

	Means 2006		Means 2007		Difference to rec. children	
	Rec. 2006	Non-rec. 2006	Rec. 2007	Rep. 2007	Non-rec. 2006	Rep. 2007
Child						
Female	0.48	0.36	0.48	0.36	-0.12	-0.12
Age (in months)	72.02	67.4	71.64	79.23	-4.53	7.59
Non-German mother tongue	0.02	0.03	0.02	0.02	0.01	0.00
Birth weight (in kg)	3.39	3.23	3.38	3.23	-0.16	-0.15
Child care > 3 years	0.70	0.49	0.69	0.80	-0.21	0.11
Early attendee	0.05	0.18	0.05	0.00	0.13	-0.05
Late attendee	0.13	0.00	0.09	0.85	-0.13	0.76
Developmental impairments						
Cognitive development	0.11	0.50	0.13	0.33	0.39	0.20
Socio-emotional development	0.08	0.34	0.08	0.18	0.26	0.10
Motor development	0.12	0.44	0.15	0.24	0.32	0.09
Health	0.39	0.52	0.37	0.45	0.13	0.08
Background						
Low SES	0.18	0.32	0.17	0.29	0.14	0.12
Medium SES	0.55	0.51	0.54	0.54	-0.04	0.00
High SES	0.26	0.17	0.29	0.17	-0.09	-0.12
Single Parent	0.17	0.21	0.17	0.20	0.04	0.03
Siblings	0.66	0.68	0.02	0.65	0.03	
N	*20,717*	*1,970*	*19,195*	*1,970*	*20,717* *1,970*	*19,195* *1,970*

Data Source: Health Ministry of Brandenburg 2006 and 2007. The number of observations is the total number without considering missings.The following variables have missings: non-German mother tongue, birth weight, child care, social status, single parent and number of siblings. The maximum share of missing values in 2006 (2007) amounts to 3.9% (6.6%) for the recommended and to 6.7% (8.8%) for the non-recommended (repeating) children.

points in 2007.[19] Albeit smaller, the difference for 2007 is still positive. This indicates that the developmental status of the group of repeaters improves but also that they are on average still more likely to show impairments than the group of children they enter school with. Nevertheless, 99.4% of the repeaters are recommended for school.

The multivariate results presented in Table 2.4 confirm the mean comparisons. Non-recommended children catch up in all screening dimensions by delaying school entry if compared to the reference group of non-repeating, recommended children in 2006. Children who are not recommended in 2006 have, given all other characteristics, a prevalence of cognitive development impairments 38.9% higher than recommended children. After a one-year delay this difference drops to 11.4%. Hence, although they delayed school entry and are above the age average now, they still show development impairments with a significantly higher probability than an average non-repeating, recommended child in 2006. The same holds for the other three developmental dimensions. However, children catch up to a lesser extent with respect to health.

In order to consider heterogenous results of delaying school with respect to children's age, we additionally calculate the risk of developmental disorders separately for three different age groups: the young children born after September 2000 who attend the first examination a year earlier than they would have to, the middle-aged children born between April and September 2000, and the old children born before April 2000. Looking at these age groups reveals that older non-recommended children have more often problems with cognitive development, motor development and health, while younger children only show developmental impairments with respect to the socio-

[19]For cognitive impairments, the 2006 gap of 39 percentage points is calculated as the difference between non-recommended children, of whom 50% show cognitive impairments, and recommended children, of whom 11% show cognitive impairments. For 2007, it is the gap between repeaters (who are most likely the non-recommended children of 2006 examined one year later), of whom now 33% show cognitive impairments, and recommended children in 2007, of whom 13% show cognitive impairments (see Table 2.3).

Table 2.4: Probit Regression of Developmental Outcomes as Dependent Variable: Average Partial Effects for Repeating Children

	Cognitive	Socio-emotional	Motor	Health
All children				
Non-recommended 2006	0.389 ***	0.261***	0.286***	0.122***
	(0.011)	(0.011)	(0.011)	(0.012)
Repeater 2007	0.114 ***	0.055***	0.081***	0.056***
	(0.016)	(0.013)	(0.014)	(0.018)
Young children				
Non-recommended 2006	0.279 ***	0.253***	0.226***	0.091***
	(0.025)	(0.025)	(0.026)	(0.029)
Repeater 2007	0.096 ***	0.048**	0.047**	0.083**
	(0.023)	(0.019)	(0.022)	(0.029)
Middle-aged children				
Non-recommended 2006	0.391 ***	0.267***	0.285***	0.120***
	(0.013)	(0.013)	(0.014)	(0.014)
Repeater 2007	0.095 ***	0.043**	0.077***	0.022
	(0.020)	(0.017)	(0.018)	(0.023)
Old children				
Non-recommended 2006	0.527 ***	0.239***	0.367***	0.164***
	(0.029)	(0.030)	(0.032)	(0.033)
Repeater 2007	0.302 ***	0.127***	0.284***	0.193***
	(0.039)	(0.035)	(0.037)	(0.040)
N		*43,789*		

Data Source: Health Ministry of Brandenburg 2006 and 2007. */**/*** indicate significance at the 10/5/1 percent level. Regression using the pooled sample of 2006 and 2007 and the estimation as described in Equation 2.3. The partial effects for the dummy variables "Non-recommended 2006" and "Repeater 2007" are calculated as treatment effects on the treated, i.e. they are averaged within the group of non-recommended children 2006 and Repeater 2007, respectively. Control Variables for children, parental background, month of examination and missing dummies are included. Child controls include variables female, non-German mother tongue, birth weight, child care duration longer than 3 years as well as dummies for early and late attendees. Control variables on family background include dummies for socio-economic status, single parenthood and siblings living in the household. The month of examination is controlled for by dummy variables. Missing dummies are included to indicate observations with missing values in one of the variables. Missings are set to zero (dummy variables) or to the mean (continuous variables) and are included in the regression.

emotional dimension more often. This shows that young children are frequently held back solely due to age and not because of developmental impairments.

One year later, almost all age groups show fewer impairments in all screening dimensions. Only within the group of older children, more health disorders are observed in 2007. In general, younger children seem to catch up to a larger extent than older children, an exception being the cognitive dimension in which the oldest children improve to a similar extent. It might be easier for the younger non-recommended children (who have less severe problems) to improve during the year. Delaying school entry should, therefore, be combined with interventions and encouragement especially for children who are already relatively old in their school cohort.

The results of the second part of our analysis suggest that delaying school entry allows retained children to improve. Their developmental status remains below average, but developmental gaps are closing at least to some extent during the one-year delay. Furthermore, younger children seem to catch up more often. Regarding the literature on school entry age, our results also indicate that school entrance screenings can be an opportunity to attenuate the disadvantages of fixed cutoff dates for relatively young children by means of delaying school entry.

2.6 Conclusion

In this paper we use novel and unique administrative data of a school entrance screening to analyze how early gaps in age and development influence children's probability to be recommended to start school at the regular age and whether developmental gaps close by delaying school entry. This is important since the previous literature on school entry age has shown that a strict application of cutoff dates leads to within-cohort differences in age which have large effects on school performance. The literature also finds OLS estimates of the age effect to be smaller than the causal IV effects and mainly attributes these differences to early and late enrollment, i.e. non-compliance with the fixed cutoff dates. Our study sheds light on the reasons for the different effect sizes of OLS and IV estimates by studying the determinants of school entry in the presence of school entrance screenings, which allow a more flexible school entry. Furthermore, we show if and how school entrance screenings reduce performance gaps in a class and, consequently, whether disadvantages for children born in the summer months induced by fixed cutoffs are mitigated.

Our results indicate that age and developmental status are important predictors for school recommendation. Impairments in cognitive, socio-emotional and motor development as well as health are negatively related to the probability to receive a school recommendation. Moreover, younger children are less likely to be recommended for school. This occurs for two reasons: First, they show developmental impairments more often. Second, they have a lower probability of being recommended per se. The probability to be recommended for school increases by 1.6 percentage points per month of age, all else being equal. The influence of age is of particular importance to the children who are born in months close to the cutoff month as they are always the youngest. By not recommending younger and developmentally disordered children, the screenings set a minimal developmental requirement which mitigates the developmental gaps within a class.

Delaying school entry allows children to improve with respect to developmental status although their developmental status remains below average. Especially children who are still fairly young when being retained catch up during a one-year delay of school entry. This might be easier for them as a smaller fraction of non-recommended younger children shows developmental impairments in the first place. However, after the delay of one year, the repeating children of all ages still show more developmental impairments than the average of the recommended children. Nevertheless, performance differences and thus disadvantages for younger children are attenuated by school entrance screenings.

Pediatricians seem to be sensitive with regard to child age and tend to deny recommendation for very young children. They either anticipate the improvement of younger children during a one-year delay or might want to place them into a more favorable age position in the cohort of the following year. School entrance screenings thus can harmonize school entrance cohorts with respect to age and developmental differences.

Fixed cutoff rules, which have been studied in the recent school entry literature, determine school entry solely by age, while entrance screenings also consider a child's developmental status. Our paper shows that, in general, flexible school entry rules taking – besides age – also children's development into account mitigate the disadvantages for relatively young children born in summer as described by the recent literature on school entry age.

However, the question remains of whether school entrance screenings are a beneficial policy. An answer to this question requires knowledge of the direct and indirect costs as well as the monetary benefits of the screenings and delayed school entry. This involves an assessment of the long-term consequences of delaying school entry, relating the possible benefits of better school performance to the forgone earnings of entering the labor market one year later. Thus, a cost-benefit analysis of school entrance screenings, similar to the cost-benefit analysis of the optimal school starting age by Borghans and Diris (2010), is a highly desirable and interesting topic for future research.

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Appendix

School entrance screening in Brandenburg

The school entrance screening in Brandenburg is based on a core set of indicators of the International Classification of Functioning, Disability and Health (ICF) developed by the World Health Organization (WHO). Information on body and mental health of the child is obtained from observation of the pediatrician, interviews with parents and child as well as medical assessments. Qualifiers are used to indicate the degree of an impairment in three levels – mild, moderate and severe (Landesgesundheitsamt Brandenburg, 2008).

The examination serves as a check-up for age-appropriate physical and psychological development. For the estimations, we use indicators on developmental status with regard to cognitive abilities, socio-emotional wellbeing, motor skills and health. All of the four dimensions are measured using several sub-tests, which are described in more detail in the following.

The assessment of cognitive development includes measures for:

- articulation
- expressive language
- receptive language
- general intelligence

Cognitive development is measured using four sub-tests of the "Basisdiagnostik für umschriebene Entwicklungsstörungen im Vorschulalter", (BUEVA, Esser and Wyschkon, 2002) to detect developmental language disorders. The sub-tests include an articulation test (Möhring (1939)) and a grammar test for expressive language (PET, Angermaier, 1974). For children who are affected by a disorder of speech and language according to these tests, two further tests are administered, one on expressive language disorders (PET, Angermaier, 1974) and one on general intelligence (Columbia Mental Maturity Scale, CMM, Burgemeister et al., 1972). The last one is a nonverbal test and can be used for children who showed difficulties with speech and language.

The assessment of socio-emotional development includes measures for:

- anxiety disorder
- anti-social behavior
- attention deficit hyperactivity disorder (ADHD)
- enuresis

Psychiatric disorders in socio-emotional development are screened using questions from the "Mannheimer Elterninterview" (MEI, Esser et al., 1989). The assessment includes measures for anxiety, anti-social (i.e. aggressive) behavior, attention deficit hyperactivity disorder (ADHD) and enuresis. The questions used for diagnosis are displayed in Figure A.2.1.

The assessment of motor development includes measures for gross motor skills to assess:

- power
- coordination
- dynamic and static balance

Motor impairments are assessed using tests on gross motor skills. The development of motor functions is important for the overall development of perception and cognition. Although there seems to be no systematic relationship to later school performance

Figure A.2.1: Measures of Psychiatric Disorders in Socio-emotional Development

My child…	**Agree**	**Disagree**	**Classification by federal health office**
gets distracted easily while playing at home	○	○	**ADHD:** agreed to both items of "at home" or "at the nursery" → ADHD
gets distracted easily at the nursery	○	○	
is very restive and fidgety and can´t sit still at home (e. g. while eating)	○	○	
is very restive and fidgety and can´t sit still at the nursery	○	○	
is often not following directions at home	○	○	**Anti social behavior:** 2 of 3 items agreed → affective-social disorder
is often not following directions at the nursery	○	○	
is often involved in fights with other children	○	○	
is often joshed, teased or beaten by other children	○	○	**Anxiety disorder:** both items agreed → affective-social disorder
is afraid of other children	○	○	
wets the bed at least once a week	○	○	**Enuresis:** agreed → enuresis

Source: Landesgesundheitsamt Brandenburg (2008).

(Esser and Schlack, 2009; Esser and Wyschkon, 2000), motor skill problems and poor performance in physical education might put these children at higher risk for being bullied (Bejerot and Humble, 2007). Tests used include standing and jumping on one leg as well as walking in a straight line using tandem gait (heel-to-toe-walking).

The assessment of body health includes the following domains:

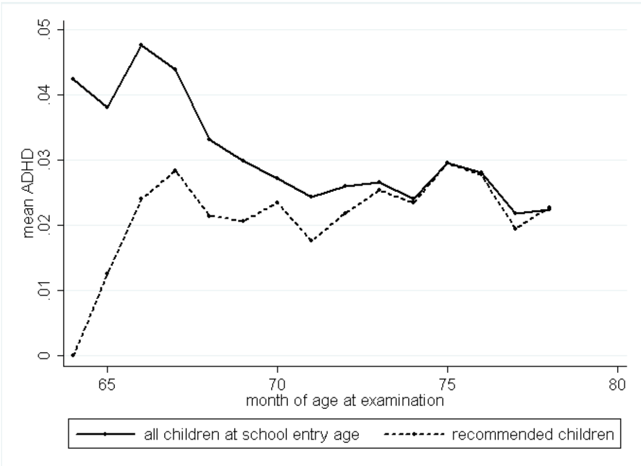
- sex, age in months
- height, weight, BMI
- allergies and asthma
- musculoskeletal system
- endocrine system
- hearing and seeing
- skin

The sub-tests used are described in a handbook, which is available to all of the government pediatricians who administer the examination(Landesgesundheitsamt Brandenburg, 2008). The results are collected in a standard form and completed by the information on family background variables. These include:

- parental education and labor force participation
- mother tongue of the child
- number of children in household
- number of adults in household
- duration of child care participation

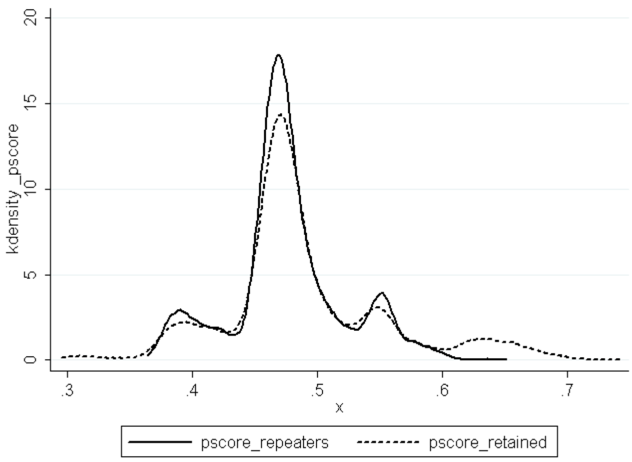
Figures and Tables

Figure A.2.2: ADHD Behavior by Month of Age at Examination



Data Source: Health Ministry of Brandenburg 2006, own calculations.

Figure A.2.3: Area of Common Support in Nearest Neighbor Matching



Data Source: Health Ministry of Brandenburg 2006 and 2007, own calculations.

Table A.2.1: Average Partial Effects for the Control Variables not Displayed in Table 2.2 (2006)

	Average partial effects					
	(I)	(II)	(III)	(IV)	(V)	(VI)
Child Controls						
Female	0.051***	0.022***	0.022***	0.021***	0.022***	0.022***
Non-German	0.002	-0.017	-0.017	-0.016	-0.017	-0.017
Birth Weight (in kg)	0.033***	0.021***	0.021***	0.021***	0.021***	0.021***
Child care > 3 years	0.029***	0.022***	0.022***	0.021***	0.022***	0.022***
Early attendee	0.014**	0.010*	0.009*	0.007	0.009*	0.009*
Late attendee	0.027*	0.045***	0.043***	0.034***	0.044***	0.044***
Family Background						
Medium SES	0.051***	0.015***	0.015***	0.015***	0.015***	0.015***
High SES	0.077***	0.036***	0.036***	0.036***	0.036***	0.036***
Single Parent	0.003	0.005	0.006	0.006	0.005	0.005
Siblings	-0.011***	-0.002	-0.002	-0.002	-0.002	-0.002
Month Dummies						
January (and before)	-0.006	0.017***	0.017***	0.016***	0.017***	0.017***
February	0.004	0.011***	0.011***	0.011***	0.011***	0.011***
April	-0.023***	-0.022***	-0.022***	-0.022***	-0.022***	-0.022***
May (and after)	-0.074***	-0.058***	-0.058***	-0.057***	-0.058***	-0.058***
Missing Dummies						
Mother-tongue	-0.042***	-0.024**	-0.024**	-0.024**	-0.024**	-0.024**
Birth weight	-0.046***	-0.023***	-0.023***	-0.023***	-0.023***	-0.023***
Child care	0.014*	0.009	0.009	0.009	0.009	0.009
Siblings	-0.072	-0.032	-0.032	-0.033	-0.032	-0.032
Parental situation	0.045*	0.019	0.019	0.019	0.019	0.019
SES	0.009	0.006	0.006	0.005	0.006	0.006

Data Source: Health Ministry of Brandenburg 2006. */**/*** indicates significance at the 10/5/1 percent level. Non-German refers to non-German mother tongue. The examination is predominantly taken from January to April; however, there are very few children tested in the months June to December. The control variable for month January thus includes also the months October, November, December. The variable for month May includes also the months June, July, August and September. Reference category is March as this is the month where most examinations are taken.

Table A.2.2: Probit Regression of School Recommendation on Age Categories and Developmental Status (2006)

	Average partial effects
Very young children (born after June 2000)	*ref.*
Young children (born April-June 2000)	0.060*** (0.003)
Middle-aged children (born Jan.-March 2000)	0.086*** (0.003)
Old children (born before Jan. 2000)	0.093*** (0.003)
Development	
Cognitive	-0.156***
	(0.007)
Socio-emotional	-0.102***
	(0.007)
Motor	-0.068***
	(0.005)
Health	-0.009***
	(0.003)
Child controls	*yes*
Family background	*yes*
Month of examination	*yes*
Missing dummies	*yes*
Pseudo$-R^2$	0.3765
N	22,687

Data Source: Health Ministry of Brandenburg 2006, own calculations. */**/*** indicate significance at the 10/5/1 percent level. Child controls include variables female, non-German mother tongue, birth weight, child care duration longer than 3 years as well as dummies for early and late attendees. Control variables on family background include dummies for socio-economic status, single parenthood and siblings living in the household. The month of examination is controlled for by dummy variables. Missing dummies are included to indicate observations with missing values in one of the variables. Missings are set to zero (dummy variables) or to the mean (continuous variables) and included in the regression.

Table A.2.3: Means for Total and Recommended Cohort

		Mean		t-test	
Variable	Sample	Treated	Control	t	$p > \|t\|$
Female	Unmatched	0.356	0.363	-0.420	0.677
	Matched	0.356	0.363	-0.430	0.666
Year of birth	Unmatched	2000	2000	-1.010	0.312
	Matched	2000	2000	-0.520	0.600
Month of birth	Unmatched	7.590	7.634	-0.590	0.555
	Matched	7.590	7.567	0.300	0.764
Non-German	Unmatched	0.027	0.020	1.500	0.134
	Matched	0.027	0.021	1.140	0.253
Birth weight	Unmatched	3.238	3.258	-0.980	0.325
	Matched	3.238	3.236	0.130	0.895
Maternal school education	Unmatched	2.129	1.990	6.750	0.000
	Matched	2.129	2.000	6.100	0.000
Single parenthood	Unmatched	0.203	0.213	-0.810	0.415
	Matched	0.203	0.202	0.120	0.905
Siblings	Matched	0.673	0.680	-0.500	0.618
	Unmatched	0.673	0.678	-0.340	0.734

Data Source: Health Ministry of Brandenburg 2006 and 2007.

3 The Effects of the Bologna Process on College Enrollment and Drop-out Rates *

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Horstschräer, Julia and Maresa Sprietsma (2010): The Effects of the Bologna Process on College Enrollment and Drop-out Rates, ZEW Discussion Paper No. 10-018, Mannheim.

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Abstract

This paper estimates the short-run effects of the Bologna Process, a change in degree regulations such that students need less time to earn a first degree, on college enrollment and drop-out rates. We use variation in the timing of the reform at the university department level to identify the effects of the reform based on longitudinal administrative student data from Germany. Results differ between subjects, but for most subjects we find no significant effects on college enrollment or drop-out rates.

Keywords: Higher education, college enrollment, Bologna Process

JEL: C23, I28, I21

3.1 Introduction

Several European countries have introduced new types of degrees in tertiary education over the last few years with the aim of creating a harmonized European Higher Education Area. During the so called 'Bologna Process', national degree systems were to be gradually replaced with a two-tier degree system based on an undergraduate (Bachelor) and a graduate (Master) cycle. Some European countries, such as the United Kingdom, were already operating under such a Bachelor-Master system, but other countries, e.g. Italy, Portugal and Germany, needed to adjust their higher education degree system according to the Bologna declaration (European Ministers of Education, 1999).

The traditional study programs in Germany were usually designed to last four to five years and did not include a separate undergraduate degree. However, in 1999, before the change of degree regulations, only 33% of the students in Germany, in fact, graduated within five years (OECD, 2001). After the introduction of the two-tier Bachelor-Master degree system, students can now achieve a first degree within three years. As a consequence, obtaining a first degree qualifying for the labor market has become less costly than under the old degree system. This could encourage more students to invest in higher education and to finish their studies.

One of the political objectives of the Bologna reform in Germany was indeed to increase the number of higher education graduates to address the increasing demand for high-skilled personnel. According to theory, direct and indirect costs of studying are a major determinant of the decision to pursue tertiary education (Becker, 1964). However, empirical evidence on students' financial constraints with respect to higher education is mixed (Carneiro and Heckman, 2002; Dearden et al., 2004; Vandenberghe, 2007), and the returns to the new Bachelor and Master degrees are still uncertain. From a theoretical point of view, it is therefore a priori unclear whether the Bologna Process with its major change to shorter study programs has had an effect on college enrollment and drop-out rates.

Existing evidence on the impact of the introduction of the Bachelor degree in the framework of the Bologna process is limited. This is due to the fact that the reform has only been implemented very recently and that it was too early to measure its effects up to now. The literature does provide numerous descriptions of the implementation process (e.g Kehm and Teichler, 2006), but to our knowledge, only few papers provide causal evidence regarding the impact of the change in degree regulations on enrollment and drop-out rates as yet. For instance, Portela et al. (2009) compute the effect of the Bachelor implementation on the number of applications by university department in Portugal. They find that the number of applicants is significantly higher at departments that implemented the Bachelor degree than at those departments that still award traditional degrees. Using survey data of secondary school graduates in Italy, Cappellari and Lucifora (2009) provide evidence that the enrollment rate increased by 15% in the period after the reform. Moreover, case studies of Italian universities reveal that the individual probability of dropping out did not change significantly after the implementation of the Bologna reform (Boero et al., 2005; Bratti et al., 2006).

Our paper contributes to the literature by addressing the question of whether the shorter duration of study programs induced by the Bologna reform affects student enrollment and drop-out rates. We add to the as yet scarce literature on the impact of the Bologna Process by providing first empirical evidence on the effects of the reform for Germany.

Using administrative data on all German students from 1998 to 2008, we estimate the short-term effects of the implementation of the Bachelor degree, which leads to a first degree in a shorter period of time, on student enrollment and drop-out rates at the university department level. We do not look at graduation rates because it is still too early to assess them. We use differences in the timing of the implementation of the Bachelor degrees at the university department level to identify the effects of the reform. Estimating a fixed effects model, we find that the introduction of the Bachelor degree has no significant impact on enrollment or drop-out rates for most subjects at this stage of the reform process. We cannot distinguish the effect of the introduction of the Bachelor degree from that of simultaneous changes in the admission requirements. We therefore estimate these two effects jointly, as if changes in admission requirements were part of the Bologna process, which from a policy point of view is indeed the case.

In the remainder of the paper, we first present the data and descriptive statistics in Section 3.2. Section 3.3 then provides the identification strategy and assumptions, followed by the empirical results and interpretation in Section 3.4. Section 3.5 concludes.

3.2 Data and Descriptive Statistics

We use administrative data on all German higher education students for the years 1998 to 2008.[1] More specifically, we use the data collected during the winter semesters (October to March), which include every enrolled student in that academic year. The advantage of the administrative student data is that we can observe all students in Germany over a long period of time. The data contain detailed information on the course of studies and a limited number of student background variables. In addition, we use institutional data on the quality of universities provided by the CHE (Centre

[1]Statistical Office Germany, Higher Education Statistics. Data are available as from 1995.

for Higher Education Development).[2] This data is collected for the purpose of a national ranking of higher education departments and is available for a majority of subjects and universities.

Due to the absence of an individual panel identifier, we aggregate the data at the level of university departments. In order to obtain a balanced panel of departments, departments opening or closing during the observation period are dropped. Table 3.1 lists the number of departments included in our analysis for each of the 19 subjects.[3] Subjects in which the implementation of the reform had not started until 2008, such as medical studies and law, were excluded from the analysis. Students of a teaching degree ('Lehramt') are not considered either because the reform of the degree system is still in the pilot phase. As for some years data are missing in the federal state of Hamburg, the universities of this state are excluded from the analysis as well.

The data allow us to calculate the number of first-year students, the percentage of first-year students enrolled in the Bachelor and in the traditional degree programs as well as a measure of the drop-out rate at the department level. Since the data do not allow us to identify the same student over time, the drop-out rate in year t is computed by dividing the number of second-year students in year t by the number of first-year students in year $t-1$. We thus follow cohorts of first-year students and calculate drop-out rates for each cohort. Due to the one-year time lag that is necessary in order to observe the second-year students, the latest cohort in the drop-out analysis are the first-year students of 2007. Because drop-out rates are defined

[2]For more background information see also http://www.che-ranking.de [last accessed: November 7th 2011].

[3]For the drop-out analysis, we use a slightly different sample as we need to balance the sample only over the years 1998 - 2007. The observation period for the drop-out sample ends with the first-year students of 2007; due to the one-year time lag, we need to observe the second-year students. The samples for the analysis of the first-year students and the drop-out sample also differ with respect to the definition of first-year students. For the analysis of first-year students, we define students entering the higher education system for the first time as first-year students. In the drop-out sample, we consider all students who are in the first year of their current studies.

Table 3.1: Number of Departments in the Balanced Panel for the Enrollment Analysis (1998-2008)

	Departments		Departments
All Subjects Pooled	929	German Lang. and Lit.	43
Biology	42	History	32
Business Administration	94	Industrial Engineering	53
Chemical Engineering	20	Information Systems	37
Chemistry	49	Mathematics	56
Computer sciences	78	Mechanical Engineering	82
Construction Engineering	52	Physics	50
Economics	25	Political Science	31
Electrical Engineering	83	Psychology	39
English Lang. and Lit.	40	Sociology	23

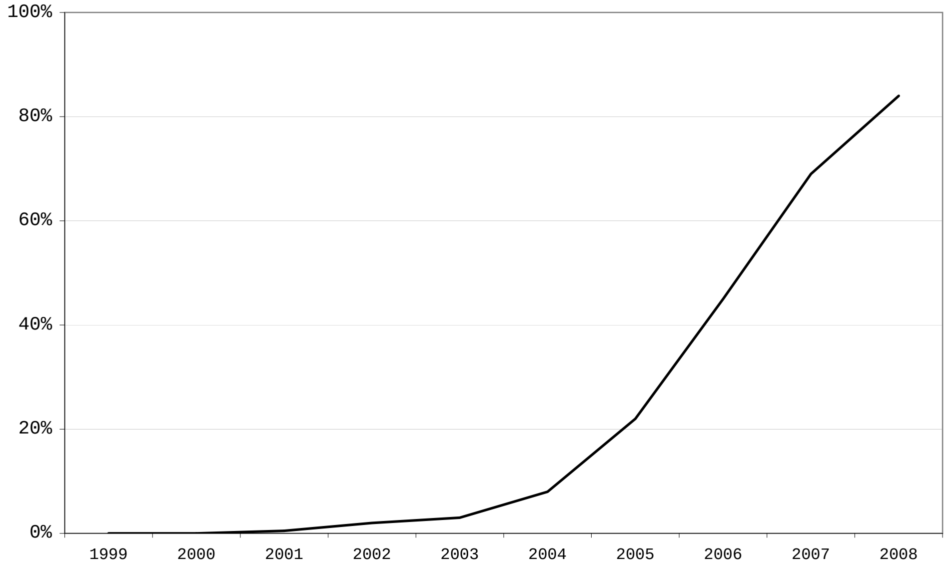
Data Source: Administrative Student Data (1998-2008), own calculations.

at the level of the university departments, students who change university or subject are counted as drop-outs. The drop-out rate is therefore a measure of the capacity of the department to retain its students. Whether they switch or give up studying as a whole cannot be distinguished.

The change in degree regulation due to the Bologna Process was implemented in Germany as from the academic year 2000/01. University departments were free to decide in which year they would start offering Bachelor programs. In this paper, a university department is considered to have implemented the Bachelor (BachDept dummy equals one) if all first-year students are attending a Bachelor program. Figure 3.1 shows the share of departments that implemented the new degree over time for all subjects pooled. We observe that the Bachelor degree started taking off as from 2004. In the academic year 2008-2009, at the end of the observation period, 86 % of the university departments had switched to the Bachelor degree.[4] Figures A.3.1 to A.3.4

[4]The observation period for the drop-outs ends with the cohort of the first-year students of 2007. By then, on average 72% of the departments had introduced the Bachelor degree.

Figure 3.1: Share of Departments Offering only the Bachelor Degree (by Year and Subject, 1999-2008)



Data Source: Administrative Student Data (1999-2008), own calculations.

in the Appendix show that the timing of the transition to the Bachelor degree was similar for all different subjects.

Summary statistics for the number of first-year students and the drop-out rates over all academic years are given in Table 3.2 and Table 3.3. The tables also depict the statistics separately for departments that switched to the Bachelor degree and for those that still operate under the traditional degree system. Pooled across all subjects, the Bachelor departments are significantly smaller than departments that have not yet implemented the reform (see Table 3.2). However, the difference is not significant in half of the subjects, and the relative size of Bachelor and traditional degree departments varies across disciplines. We observe considerable variation in the average department size by subject as well. While business administration departments, for instance, have 146 first-year students on average, history and chemical engineering departments are the smallest with about 40 first-year students.

Pooled across all subjects, drop-out rates are not significantly different in Bachelor versus traditional degree departments (see Table 3.3). But similarly to the enrollment numbers, important differences between subjects emerge. In about half of the subjects, differences in drop-out rates between Bachelor and traditional degree departments exist in either positive or negative directions. Drop-out rates of more than 30% are observed in the fields of chemistry, English language and literature as well as in mathematics, whereas psychology departments only have an average drop-out rate of about 8%.

Table 3.2: Average Number of First-year Students by Department, Subject and Transition to the Bachelor Program (1998-2008)

	Pooled		Bachelor Dept=0			Bachelor Dept=1			t-test
	Mean	Std. Dev.	Mean	Std. Dev.	Nb of Depts	Mean	Std. Dev.	Nb of Depts	
All Subjects Pooled	84.84	(74.03)	87.02	(76.57)	8054	76.70	(63.07)	2165	***
Biology	96.26	(39.82)	95.21	(37.16)	356	99.76	(47.71)	106	
Business Admin.	145.98	(89.45)	147.58	(90.06)	831	139.44	(86.83)	203	
Chemical Engin.	41.32	(23.27)	37.95	(23.12)	159	50.11	(21.44)	61	***
Chemistry	69.54	(39.45)	67.62	(39.38)	409	75.58	(39.22)	130	**
Computer Sciences	95.14	(83.63)	103.92	(90.69)	664	65.08	(40.39)	194	***
Construction Engin.	74.50	(38.94)	75.73	(39.12)	442	70.30	(38.17)	130	
Economics	108.40	(83.61)	118.47	(88.83)	210	75.88	(52.50)	65	***
Electrical Engin.	75.45	(60.03)	79.37	(62.02)	740	58.68	(47.25)	173	***
English Lang. and Lit.	51.50	(38.59)	48.20	(31.45)	316	59.94	(51.79)	124	***
German Lang. and Lit.	87.93	(83.06)	90.82	(83.59)	366	78.05	(80.83)	107	
History	38.35	(35.55)	35.17	(32.65)	242	45.36	(40.51)	110	**
Industrial Engin.	92.50	(78.09)	93.74	(78.19)	474	87.11	(77.78)	109	
Information Systems	62.40	(35.72)	65.42	(37.26)	288	55.08	(30.63)	119	***
Mathematics	50.62	(49.02)	48.78	(47.56)	518	60.37	(55.36)	98	**
Mechanical Engin.	119.44	(118.63)	122.35	(122.29)	750	105.09	(97.73)	152	
Physics	62.65	(42.11)	62.95	(41.35)	442	61.42	(45.28)	108	
Political Sciences	71.20	(49.84)	71.81	(52.80)	268	68.95	(37.26)	73	
Psychology	67.78	(26.34)	67.08	(26.47)	383	73.61	(24.79)	46	
Sociology	71.92	(50.36)	74.11	(51.40)	196	64.42	(46.25)	57	

Note: Administrative Student Data (1998-2008); *, **, *** respectively stand for statistical significance of the difference at the 10, 5 and 1% confidence level.

Table 3.3: Drop-out Rates by Department, Subject and Transition to the Bachelor Program (1998-2008)

	Pooled		Bachelor Dept=0			Bachelor Dept=1			t-test
	Mean	Std. Dev.	Mean	Std. Dev.	Nb of Depts	Mean	Std. Dev.	Nb of Depts	
All Subjects Pooled	0.20	(0.25)	0.20	(0.26)	8073	0.19	(0.18)	1487	
Biology	0.14	(0.11)	0.13	(0.10)	363	0.19	(0.11)	67	***
Business Admin.	0.12	(0.16)	0.12	(0.16)	811	0.12	(0.18)	139	
Chemical Engin.	0.21	(0.24)	0.21	(0.26)	168	0.18	(0.16)	42	
Chemistry	0.31	(0.14)	0.31	(0.13)	414	0.31	(0.15)	86	
Computer Sciences	0.20	(0.14)	0.19	(0.14)	654	0.21	(0.15)	136	
Construction Engin.	0.19	(0.14)	0.19	(0.13)	436	0.17	(0.15)	94	
Economics	0.29	(0.15)	0.29	(0.15)	218	0.29	(0.17)	42	
Electrical Engin.	0.18	(0.57)	0.18	(0.62)	724	0.21	(0.17)	126	
English Lang. and Lit.	0.30	(0.17)	0.33	(0.16)	324	0.20	(0.17)	86	***
German Lang. and Lit.	0.27	(0.19)	0.29	(0.19)	397	0.17	(0.17)	73	***
History	0.26	(0.37)	0.27	(0.42)	253	0.22	(0.14)	87	
Industrial Engin.	0.16	(0.19)	0.17	(0.19)	468	0.15	(0.22)	72	
Information Systems	0.14	(0.15)	0.13	(0.15)	288	0.19	(0.13)	82	***
Mathematics	0.30	(0.19)	0.30	(0.20)	552	0.32	(0.16)	58	
Mechanical Engin.	0.16	(0.15)	0.17	(0.16)	714	0.14	(0.12)	116	*
Physics	0.24	(0.11)	0.23	(0.11)	441	0.27	(0.14)	69	***
Political Sciences	0.15	(0.17)	0.15	(0.18)	261	0.14	(0.12)	49	
Psychology	0.08	(0.10)	0.07	(0.08)	384	0.14	(0.27)	26	***
Sociology	0.22	(0.19)	0.24	(0.14)	203	0.11	(0.36)	37	***

Note: Administrative Student Data (1998-2008); *, **, *** respectively stand for statistical significance of the difference at the 10, 5 and 1% confidence level.

3.3 Estimation Strategy

We estimate the number of first-year students and the drop-out rates per university department as a function of the implementation of the Bachelor degree in a fixed effects panel setting. The department fixed effects control for all time-constant observed and unobserved department characteristics. For instance, these could include regional differences in the higher education institutions or differences in the quality of the management and prestige at the university or department level. Year dummies are included to capture enrollment trends over time that may be related to e.g. changes in the expectations as to economic activity (a measure of the expected opportunity costs of studying) or to variation in the number of secondary school graduates who have acquired the formal right to attend higher education. We also include a dummy indicator for the introduction of tuition fees as two federal states introduced fees in 2006 and four federal states in 2007.[5] Finally, we include a dummy variable indicating whether a department simultaneously offered a Bachelor and a traditional degree in a given year to control for possible selection effects.

The estimated equation thus reads:

$$y_{it} = \beta_1 BachDept_{it} + \beta_2 MixDept_{it} + \beta_3 Fee_{it} + \beta_4 Year_t + \upsilon_i + \epsilon_{it} \tag{3.1}$$

where y_{it} is the natural logarithm of the number of enrolled students respectively the drop-out rate at department i in year t, $BachDept_{it}$ represents an indicator variable equal to one if the department implemented the Bachelor degree,[6] υ_i the department fixed effects and $Year_t$ represent the year dummies. $MixDept_{it}$ equals

[5]Before the year 2006, no German federal state levied tuition fees.

[6]As described above, we define that a department has implemented the Bachelor degree once all first year students are enrolled in a bachelor degree course of study.

one if traditional and new degrees coexisted in a given department in year t. Fee_{it} is a dummy variable that equals one if a federal state introduced tuition fees.

This equation is estimated pooled over all subjects as well as separately for each subject within a balanced panel of departments so that β_1 identifies the within departments effects of the Bachelor introduction. Heteroscedasticity robust standard errors are clustered by department to allow for within-department serial correlation in the error terms ϵ_{it}. Furthermore, the analyses by subject allow us to observe potential differences in the impact of the reform between subjects.

In the pooled regression, we additionally control for the number of departments in each subject per year (in the unbalanced sample) in order to take into account the effect of the total number of existing departments in a given subject and year on enrollment in the observed departments. This is not necessary in the separate estimations per subject since variation in the number of departments is captured by the year dummies. As an additional robustness check for the effect of departments that were newly established or closed down during the observation period, we also estimate the model at the subject level. That is, we regress the share of departments that implemented the Bachelor degree per subject on the total number of first-year students per subject in the unbalanced sample.

The number of first-year students (and possibly as well the drop-out rate) of a university department is determined by demand and supply of higher education. While demand is constrained by the number of students that have a secondary degree giving them access to higher education, supply of study places is constrained by the teaching capacity of universities. If the admission restrictions (for instance numerus clausus) are constant over time, the department fixed effects will account for them. However, if admission restrictions change simultaneously to the Bologna process, this will affect our estimates. We cannot distinguish the effect of the introduction of the

Bachelor degree from that of simultaneous changes in the admission requirements. We therefore estimate these two effects jointly as we consider changes in the admission requirements to be part of the Bologna Process. From a policy evaluation point of view, this seems a meaningful way to proceed since capacity constraints of universities are a real constraint to the effectiveness of the policy. Our estimates thus reflect this combined policy effect of the Bologna Process.

Our identifying assumption for the analysis on the department level is that the timing of the implementation of the reform is not related to department characteristics. In order to investigate the plausibility of this assumption, we regress the timing of the reform (that is the year in which the department implemented the Bachelor degree) on observable department characteristics before the reform. In this estimation, we include the average change in the number of first-year students (department growth) and the average number of first-year students (department size) between 1995 and 2000, i.e. before the start of the transition process. Furthermore, we include department quality measures taken from the CHE ranking data. The available department quality variables vary by subject and year. The quality measures of the ranking are collected only every 3 years, for the first time in 2001, 2002 or 2003 depending on the subject. We use the earliest available department quality measures for each subject. Depending on the subject, these may include the number of PhD students per 10 professors, the research reputation and reputation among professors, the number of citations, the amount of external funding per researcher, as well as students' evaluations of the quality of teaching, organisation, mentoring and infrastructure.

Tables 3.4 and 3.5 present the results of this estimation. It appears that, although some correlations appear significant in certain disciplines, none of the variables is significant across disciplines or consistent in the direction of the effect. We do observe that the average growth rate of physics and electrical engineering departments before 2000 is related to earlier implementation of the reform. In these two subjects, faster growing department implement the Bachelor degree earlier. This may bias the measured effect of the Bachelor reform on the number of first-year students upwards in these disciplines as the increase in the number of students related to the department trend is picked up by the Bachelor coefficient. The average department size before 2000 is significantly correlated with the timing of the transition in many subjects, but its coefficient is close to zero.

Table 3.4: Timing of the Reform and Department Characteristics I (OLS)

	Growth rate	Average size	# PhD	Res. Reput.	Reput.	Citation	Ext. $	Obs.
Biology	4.81 (5.10)	-0.00 (0.01)	-0.72 (0.42)	-0.12 (0.76)	-0.15 (0.65)	**-0.90**** **(0.40)**	**1.32***** **(0.41)**	42
Chemical Engineering	0.77 (3.36)	0.00 (0.04)	-	-	0.05 (0.61)	-	-	20
Chemistry	0.96 (1.89)	0.02 (0.02)	-0.57 (0.50)	0.71 (1.01)	-0.71 (0.79)	-0.03 (0.93)	0.37 (0.32)	49
Computer Sciences	0.46 (0.58)	**0.00**** **(0.00)**	-	-	**0.40*** **(0.22)**	-	-	78
Construction Engineering	-2.72 (1.66)	**0.02**** **(0.01)**	-	-	0.35 (0.35)	-	-	52
Economics	0.14 (1.34)	**0.01***** **(0.00)**	**-1.06**** **(0.41)**	**1.63***** **(0.38)**	**-1.63***** **(0.44)**	-	-0.17 (0.29)	25
Electrical Engineering	**-0.85*** **(0.47)**	0.00 (0.00)	-	-	-0.14 (0.22)	-	-	67
English Language and Literature	-0.48 (0.32)	0.02 (0.02)	-0.40 (0.27)	1.15 (0.77)	-0.94 (0.62)	-	-	40
German Language and Literature	-1.12 (1.47)	0.00 (0.00)	-.18 (0.38)	-	-0.03 (0.32)	-	-0.02 (0.36)	43
History	1.41 (0.95)	0.02 (0.01)	0.23 (0.40)	-	**0.79**** **(0.37)**	-	-1.02 (0.46)	32
Information Systems	0.46 (0.58)	**0.00**** **(0.00)**	-	-	**0.40*** **(0.22)**	-	-	78
Mathematics	0.34 (0.39)	**0.02*** **(0.01)**	-0.57 (0.38)	0.90 (0.90)	-0.39 (0.91)	-	0.16 (0.40)	56
Mechanical Engineering	-0.57 (0.89)	**0.01**** (0.00)	-	-	-0.06 (0.25)	-	-	82
Physics	**-2.36*** **(1.30)**	0.01 (0.01)	-0.36 (0.53)	-0.53 (0.40)	-0.57 (0.55)	0.75 (0.46)	0.36 (0.48)	50
Political Sciences	1.77 (2.19)	0.01 (0.01)	-	0.00 (1.03)	-0.39 (1.06)	-	-	31
Psychology	-3.31 (2.69)	-0.00 (0.01)	-0.09 (0.45)	-	-0.20 (0.34)	-0.14 (0.35)	0.18 (0.34)	39

Note: Administrative Student Data (1998-2008); Dep. variable: year of transition to the Bachelor degree; Robust std. err. in parentheses (clustered by department); *, **, ***: 10, 5 and 1% confidence level; regional dummies are included in all estimations; growth rate of the department is calculated based on the 5 years before the transition; ' -' department characteristic not available.

Table 3.5: Timing of the Reform and Department Characteristics II (OLS)

	Growth rate	Average size	# PhD	Res. Reput	Reput.	Quality men-toring	Quality Teach-ing	Org. study	IT	Rooms	Ext. $	Obs.
Business Administration	0.78 (0.87)	0.00 (0.00)	-	-	0.13 (0.20)	-0.00 (0.53)	**-0.71**** **(0.35)**	0.42 (0.41)	0.06 (0.27)	0.11 (0.33)	-	94
Industrial Engineering	0.81 (0.53)	**0.01***** **(0.00)**	-	-	-0.27 (0.22)	**-2.94**** **(1.40)**	0.59 (0.67)	**3.23**** **(1.30)**	0.62 (0.56)	**-1.10**** **(0.41)**	-	60
Sociology	-2.68 (0.79)	-0.01 (0.00)	-0.09 (0.08)	-0.40 (0.40)	0.80 (0.25)	-0.13 (0.13)	-1.04 (0.33)	**3.27*** **(0.36)**			0.24 (0.10)	23

Note: Administrative Student Data (1998-2008); Dep. variable: year of transition to the Bachelor degree; Robust std. err. in parentheses (clustered by department); *, **, ***: 10, 5 and 1% confidence level; regional dummies are included in all estimations; growth rate of the department is calculated based on the 5 years before the transition; ' -' department characteristic not available.

3.4 Results

In this section we present fixed effects (FE) estimates for the effect of the bachelor introduction on the log of the number of first-year students and drop-out rates.[7] In the estimation of the drop-out rate, the marginal effects are divided by the standard deviation of the outcome variables. The coefficients thus represent percentages of a standard deviation in the outcome variable. This is done to facilitate comparison of the magnitude of the results across disciplines.

Estimating the fixed effects model, we do not find a significant change in the number of first-year students due to the introduction of the new degree system with a shorter duration of studies in the pooled sample (Table 3.6).[8] The results are similar for three quarters of the subjects when estimated separately. Therefore, the reform overall does not seem to have changed the incentives to pursue higher education for the moment. Also depicted in Table 3.6 are the marginal effects for the mixed department dummies. This control dummy variable takes into account that some departments offer the traditional and the new Bachelor degree simultaneously. The effect is significant in 8 out of 19 subjects. We interpret this as the control dummy capturing the unobserved selection in characteristics of departments offering the traditional and the new degree simultaneously.

We find significantly negative effects of the Bachelor implementation on enrollment for the subjects of electrical and mechanical engineering. In these subjects, the number of first-year students in Bachelor departments is 12% lower than in departments offering the traditional degrees. A possible interpretation is that students avoid the new degrees. During the implementation process, students can indeed choose whether

[7]OLS estimates can be found in the Appendix.

[8]The estimations are based on the balanced panel. Estimations using the unbalanced panel yield similar results.

they want to apply for a Bachelor or a traditional degree department. Considering the solid reputation of German engineering degrees, students may prefer avoiding the university departments proposing the Bachelor degrees in order to pursue the traditionally renown programs. If that is the case, the departments that have implemented the reform should attract fewer students, which results in a negative estimate of the Bachelor implementation. This effect should be transitory because, once all departments have introduced the Bachelor degree, avoiding the Bachelor will no longer be an option.[9]

Table 3.6: Marginal Effects of the Bachelor Implementation on the Number of First-year Students (OLS, Department Fixed Effects)

	Bachelor Dpt.		Mixed Dpt.		
	Marg. Eff.	Std. Err.	Marg. Eff.	Std. Err.	N
All Subjects Pooled	0.02	(0.03)	**0.10*** **	(0.02)	10,219
Biology	0.09	(0.06)	0.03	(0.05)	462
Business Admin.	0.09	(0.11)	**0.10***	(0.05)	1,034
Chemical Engineering	0.11	(0.17)	**0.47*** **	(0.14)	220
Chemistry	0.06	(0.07)	**0.11***	(0.06)	539
Computer sciences	**0.14***	(0.07)	0.07	(0.07)	858
Construction Engineering	-0.09	(0.07)	-0.00	(0.05)	572
Economics	0.07	(0.12)	0.02	(0.14)	275
Electrical Engineering	**-0.12***	(0.07)	**0.09***	(0.05)	913
English Lang. and Lit.	**0.35** **	(0.16)	**0.25** **	(0.11)	440
German Lang. and Lit.	**0.32** **	(0.15)	0.17	(0.13)	473
History	0.17	(0.14)	-0.05	(0.13)	352
Industr. Engineering	0.01	(0.06)	-0.02	(0.08)	583
Information Systems	0.08	(0.10)	-0.00	(0.06)	407
Mathematics	0.05	(0.13)	**0.16***	(0.09)	616
Mechanical Engineering	**-0.12***	(0.07)	0.03	(0.04)	902
Physics	-0.00	(0.07)	**0.18*** **	(0.06)	550
Political Science	0.25	(0.16)	0.11	(0.11)	341
Psychology	-0.03	(0.04)	**-0.185*** **	(0.04)	429
Sociology	-0.06	(0.23)	0.40	(0.20)	253

Note: Administrative Student Data (1998-2008); Dependent variable: ln(number of students per department); Year and tuition fee dummies included; Pooled estimation in addition contains subject dummies and the number of faculties per subject; *,**, ***: significance at the 10, 5 and 1% confidence level.

[9] We indeed find stronger negative effects in these disciplines using the 1998-2006 sample. The coefficients for the current sample are closer to zero and less significant.

Secondly, we find that the Bachelor introduction increases enrollment in English and German language and literature departments as well as in computer sciences departments. The first two subjects are usually chosen primarily because students are interested in the field and less because of their returns on the labor market. It is possible that the shorter duration of the new degree has made it more attractive to pursue these subjects. Furthermore, computer sciences and English language should provide relatively many opportunities for exchange with English speaking countries where the Bachelor degree already exists. The international comparability of degrees may, thus, be more relevant for these subjects.

At the subject level, controlling for year and subject fixed effects, we find that the share of Bachelor departments per subject is not significantly related to total enrollment per subject (p-value=0.258). Based on our results, we can state that the introduction of the Bachelor degree overall did not increase the number of first-year students, neither within a subject nor overall at the department level.

Regarding the drop-out rate, we find that the Bachelor implementation overall did not affect the drop-out rates in the estimation using all subjects pooled (Table 3.7).[10] Taking subjects separately, we find that the Bachelor introduction had a significant effect in four subjects. Drop-out rates seem to increase for biology departments, whereas we observe a significantly smaller drop-out rate in business administration as well as in English and German language and literature departments that have implemented the Bachelor reform. Similar to our interpretation of the increase in enrollment, the shorter duration of studies may also lead to decreasing drop-out rates. Due to lower opportunity and direct costs of studying, more students might be able and motivated to continue their studies.

[10] The estimation here is based on the balanced panel. Estimations using the unbalanced panel yield similar results.

Table 3.7: Marginal Effects of the Bachelor Implementation on Drop-out Rates (OLS, Department Fixed Effect)

	Bachelor Dept.		Mixed Dept.		
	Marg. Eff.	Std. Err.	Marg. Eff.	Std. Err.	N
All Subjects Pooled	-0.01	(0.04)	**0.11*** **	(0.04)	9,560
Biology	**0.70** **	(0.32)	**0.84*** **	(0.25)	430
Business Admin.	**-0.38** **	(0.18)	0.01	(0.12)	950
Chemical Engineering	-0.03	(0.57)	0.57	(0.43)	210
Chemistry	0.06	(0.20)	0.22	(0.17)	500
Comp. sciences	-0.05	(0.19)	0.07	(0.14)	790
Constr. Eng.	-0.07	(0.17)	-0.01	(0.13)	530
Economics	0.41	(0.29)	0.07	(0.27)	260
Electr. Eng.	0.02	(0.08)	**0.17***	(0.09)	850
English Lang.	**-0.42***	(0.23)	-0.25	(0.18)	410
German Lang.	**-0.44** **	(0.17)	-0.11	(0.15)	470
History	0.30	(0.39)	0.33	(0.24)	340
Industr. Eng.	0.07	(0.28)	-0.09	(0.13)	540
Information Systems	-0.04	(0.17)	-0.14	(0.23)	370
Mathematics	0.09	(0.15)	0.13	(0.18)	610
Mech. Eng.	-0.10	(0.21)	0.15	(0.15)	830
Physics	0.08	(0.21)	0.07	(0.15)	510
Political Science	0.00	(0.25)	0.03	(0.23)	310
Psychology	0.60	(0.44)	-0.22	(0.16)	410
Sociology	-0.23	(0.27)	0.05	(0.19)	240

Note: Administrative Student Data (1998-2008); No sign. eff. in other disciplines; Year and tuition fee dummies included; Coeff. divided by Std. Dev.; *, **, *** respectively stand for statistical significance at the 10, 5 and 1% confidence level.

For most subjects, however, we do not identify significant changes in drop-out rates due to the change in degree regulations such that students need less time to earn a first degree. This result is in line with what we would expect for several reasons. First of all, we have seen that the number of first-year students is not significantly affected by the reform and that there is no evidence of systematic selection into the Bachelor degrees with respect to family background or students' final grades in secondary school either (Mühlenweg, 2010). The composition of the student population should therefore have remained the same. Moreover, the costs of higher education have been largely covered by the German federal states. Until recently, no tuition fees have been levied. This could imply that opportunity costs are not such an important determinant of the drop-out decision.

Besides the shorter duration of study programs after the introduction of the Bologna Process, an alternative reason to expect an effect of the Bachelor implementation on drop-out rates could be the reorganization of the course of studies. However, there is no evidence that curricula have been systematically restructured during the reform (Winter et al., 2010). The existing courses of the traditional degrees were often merely split between a Bachelor and a Master program. Furthermore, students did not perceive any changes in the quality of mentoring in the Bachelor program as compared to the traditional degrees (Mühlenweg, 2010).

3.5 Conclusion

In this paper, we estimate the short-term effects of the implementation of a Bachelor degree shortening the time to a first degree on enrollment and drop-out rates. We estimate a fixed effects panel model at the level of university departments. For most subjects, we do not find a significant change in the number of first-year students due to the implementation of the Bachelor degree in Germany. Overall, the reform thus does not seem to have changed the incentives to pursue higher education for the moment.

However, differences by subjects exist. Indeed, we find significantly negative effects of the Bachelor implementation on enrollment for the subjects of electrical and mechanical engineering but an increase in enrollment in English and German language and literature departments as well as in computer sciences departments. We interpret the decrease in enrollment in mechanical and electrical engineering as a possible indication that students avoid the new degrees in these subjects because the traditional German engineering degrees have a very good international reputation. If this is the case, the observed negative effect should gradually vanish as it becomes no longer possible to avoid the Bachelor degrees. As to the increase in size of the English and German language and literature departments, it is possible that the shorter duration of the new degrees made these subjects more attractive to pursue.

Drop-out rates in most subjects do not seem to be affected by the introduction of the Bachelor degree either. Only business administration as well as English and German language and literature departments experience a declining drop-out rate, whereas drop-outs increased in biology. Business administration as well as English and German language and literature students thus seem to react as expected to the reduction in opportunity costs. This is not the case for the majority of subjects, though. It is possible that the strong financial support to the higher education sector by the German federal states reduces the relevance of the cost factor for drop-out decisions.

To conclude, it is important to note that results with respect to enrollment and drop-out rates might change once all departments will have implemented the two-tier Bachelor and Master degree system or once the labor market returns to the Bachelor degree become known.

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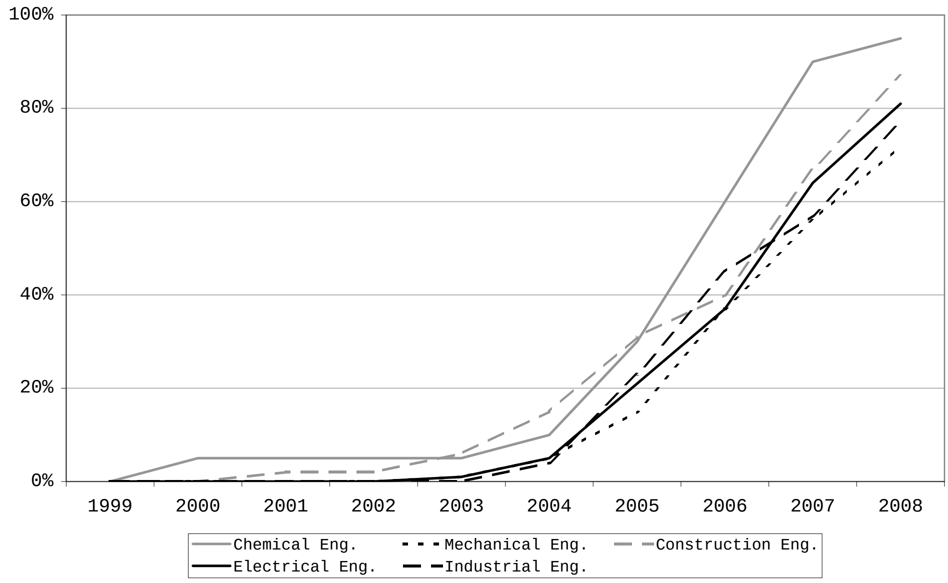
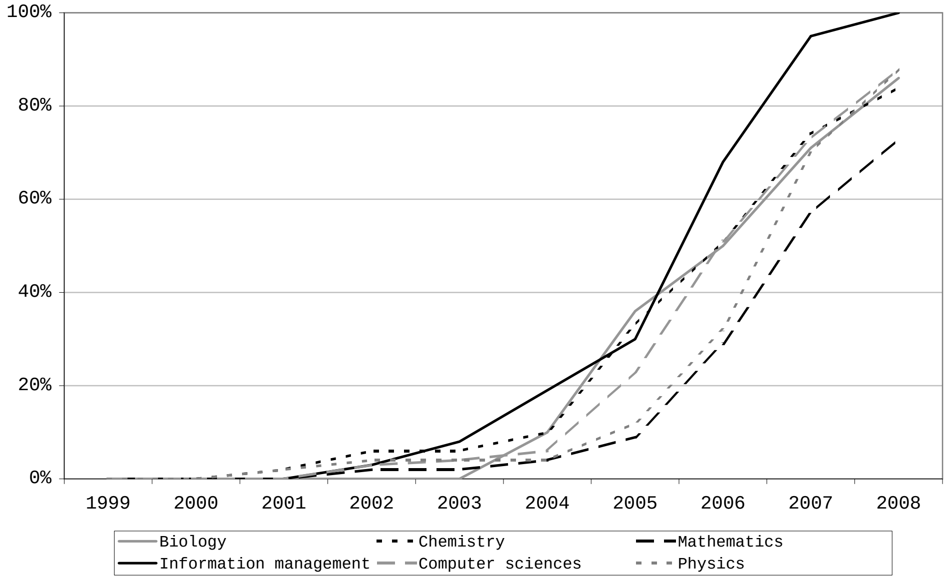
Appendix

Figure A.3.1: Share of Departments that Implemented the Bachelor Reform, by Year and Subject (1999 - 2008): I



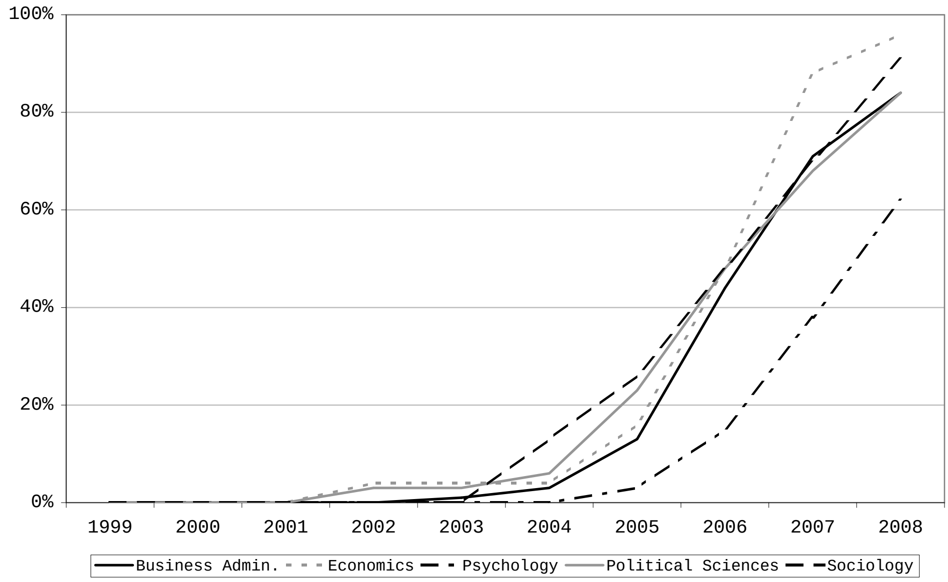
Data Source: Administrative Student Data (1999-2008), own calculations.

Figure A.3.2: Share of Departments that Implemented the Bachelor Reform, by Year and Subject (1999 - 2008): II



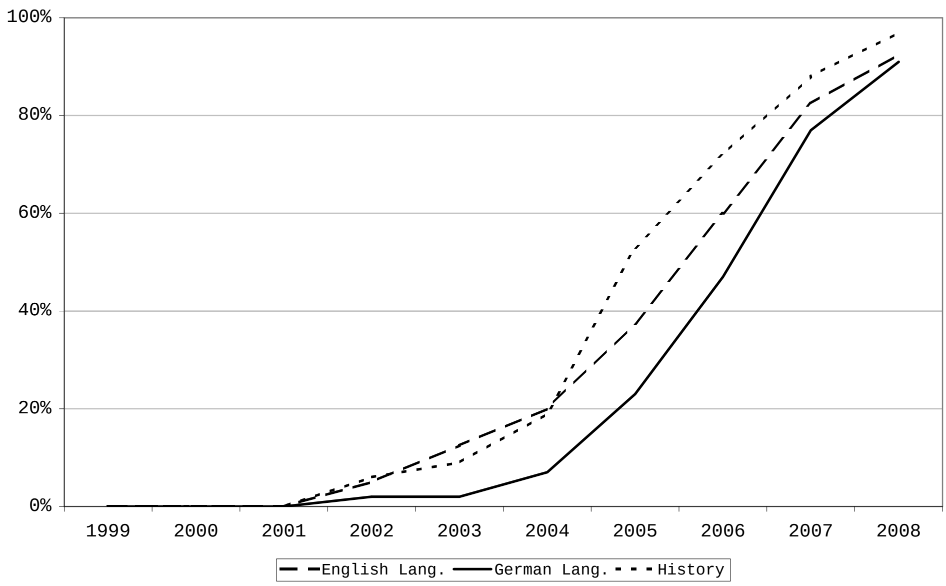
Data Source: Administrative Student Data (1999-2008), own calculations.

Figure A.3.3: Share of Departments that Implemented the Bachelor Reform, by Year and Subject (1999 - 2008): III



Data Source: Administrative Student Data (1999-2008), own calculations.

Figure A.3.4: Share of Departments that Implemented the Bachelor Reform, by Year and Subject (1999 - 2008): IV



Data Source: Administrative Student Data (1999-2008), own calculations.

Table A.3.1: Marginal Effects of the Bachelor Implementation on the Number of First-year Students (OLS)

	Bachelor Dept.		Mixed Dept.		
	Marg. Eff.	Std. Err.	Marg. Eff.	Std. Err.	N
All Subjects Pooled	**-0.14*** **	(0.04)	**0.23*** **	(0.03)	10219
Biology	0.15	(0.12)	**0.28** **	(0.11)	462
Business Admin.	0.03	(0.15)	**0.24** **	(0.09)	1,034
Chemical Engineering	0.05	(0.21)	**0.43** **	(0.15)	220
Chemistry	-0.18	(0.17)	0.07	(0.12)	539
Computer sciences	0.22	(0.14)	**0.48*** **	(0.13)	858
Construction Engineering	**-0.26* **	(0.13)	**0.18* **	(0.10)	572
Economics	**-0.65*** **	(0.19)	-0.07	(0.20)	275
Electrical Engineering	**-0.29** **	(0.10)	0.36**	(0.13)	913
English Lang. and Lit.	0.36	(0.21)	0.25	(0.15)	440
German Lang. and Lit.	-0.04	(0.17)	0.08	(0.13)	473
History	0.30	(0.29)	0.27	(0.27)	352
Industr. Engineering.	**-0.42** **	(0.17)	0.12	(0.12)	583
Information Systems	0.13	(0.16)	0.08	(0.09)	407
Mathematics	-0.10	(0.17)	**0.33** **	(0.14)	616
Mechenical Engineering.	**-0.43*** **	(0.13)	**0.24* **	(0.13)	902
Physics	**-0.48** **	(0.22)	0.11	(0.11)	550
Political Science	-0.25	(0.17)	-0.15	(0.18)	341
Psychology	-0.03	(0.11)	0.01	(0.11)	429
Sociology	-0.32	(0.23)	-0.15	(0.27)	253

Note: Administrative Student Data (1998-2008); Dependent variable: ln(number of students per department); Pooled estimation in addition contains subject dummies and the number of faculties per subject; Year and tuition fee dummies included; *, **, *** respectively stand for statistical significance at the 10, 5 and 1% confidence level; Data: 1998-2008

Table A.3.2: Marginal Effects of the Bachelor Implementation on Drop-out Rates (OLS)

	Bachelor Dept.		Mixed Dept.		
	Marg. Eff.	Std. Err.	Marg. Eff.	Std. Err.	N
All Subjects Pooled	-0.05	(0.04)	**0.06****	(0.03)	9560
Biology	**0.69****	(0.27)	**0.67*****	(0.20)	430
Business Admin.	-0.21	(0.17)	-0.06	(0.15)	950
Chemical Engineering	0.23	(0.36)	0.45	(0.28)	210
Chemistry	-0.12	(0.22)	0.10	(0.20)	500
Comp. sciences	-0.17	(0.19)	0.16	(0.13)	790
Constr. Eng.	-0.33	(0.20)	0.19	(0.23)	530
Economics	-0.09	(0.35)	-0.46	(0.31)	260
Electr. Eng.	0.00	(0.04)	0.05	(0.04)	850
English Lang.	**-0.71*****	(0.18)	**-0.37***	(0.20)	410
German Lang.	**-0.65*****	(0.17)	-0.24	(0.15)	470
History	0.11	(0.35)	0.28	(0.25)	340
Industr. Eng.	0.01	(0.18)	-0.03	(0.10)	540
Information Systems	0.00	(0.24)	0.04	(0.22)	370
Mathematics	0.05	(0.12)	0.06	(0.08)	610
Mech. Eng.	-0.08	(0.14)	**0.24***	(0.13)	830
Physics	0.26	(0.20)	0.21	(0.13)	510
Political Science	0.15	(0.27)	-0.07	(0.26)	310
Psychology	0.62	(0.43)	-0.22	(0.19)	410
Sociology	-0.29	(0.32)	0.05	(0.22)	240

Note: Administrative Student Data (1998-2008); Year and tuition fee dummies included; Coeff. divided by Std. Dev.; *, **, *** respectively stand for statistical significance at the 10, 5 and 1% confidence level; Data: 1998-2008

4 University Rankings in Action? The Importance of Rankings and an Excellence Competition for University Choice of High-Ability Students *

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Abstract

This paper analyzes how high-ability students respond to different indicators of university quality when applying for a university. Are some quality dimensions of a ranking, e.g. research reputation or mentoring more important than others? I estimate a random utility model using administrative application data of all German medical schools. As identification relies on the variation in quality indicators over time, I can disentangle the response to changes in quality indicators from the common knowledge regarding the overall university attractiveness. Results show that the ranking provides more relevant information in the quality dimensions mentoring, infrastructure and students' satisfaction than with respect to research.

Keywords: higher education, university choice, college admission

JEL: I21, I23, C25

4.1 Introduction

Every year, secondary school graduates who want to pursue higher education have to choose a university. This is a crucial decision for their future trajectories made under imperfect information regarding their own ability, university quality and the corresponding returns to a degree. From an economist's point of view, it is very important that prospective students apply for the universities that fit them best in order to maximize human capital production and to minimize drop-outs. Therefore, university rankings and indicators of excellence may provide valuable information for the decision of prospective students.

In this paper, I analyze whether high-ability students in fact use different university quality indicators as a source of information and whether some quality dimensions are more important for an applicant's decision than others. For this purpose, I estimate the effect of different quality indicators from a German university ranking – as well-established as the *U.S. News & World Report* ranking in the U.S. – on the university application decision of high-ability students. As an additional quality indicator, I use an excellence competition run by the German government, which declared some universities to be "excellence universities" and granted them extra money. Identification relies on the variation induced by changes in the ranking indicators over time and the introduction of the excellence status. This allows me to disentangle the response to changing quality indicators from the time-constant common knowledge regarding the overall university attractiveness.

In contrast to the U.S. higher education system, the German system is traditionally based on public universities, which were recognized as quite homogeneous with respect to their quality. During the last couple of years, however, several changes towards a more competitive market have been implemented. With the publication of university rankings in the media starting from the 1990's on, the quality of different institutions has become directly comparable for the first time. Furthermore, the European Bologna Declaration from 1999 induced a change in the German higher education system to create comparable tertiary degrees throughout Europe and to increase the international competitiveness of the European system of higher education.[1] From 2006 onwards, some German federal states introduced tuition fees,[2] and in 2006 and 2007, the German government has run an excellence initiative awarding extra funding to the universities with the best future concept for research. This said, it is very likely that university choice has recently become more important for prospective students. Especially, as Brewer et al. (1999) and Strayer (2002) show that the type of university an individual chooses significantly affects post-school earnings.

The theoretical literature characterizes the "College Admission Problem" as a two-sided market (Gale and Shapley, 1962; Roth and Sotomayor, 1989). On the one hand, prospective students decide where to apply and, once admitted, whether to accept the university's offer. On the other hand, universities (or a central admission authority) determine who is admitted. The admission problem can be evaluated from three different perspectives: (i) the prospective student who most likely wants to maximize his human capital, (ii) the universities which try to maximize the aggregated human capital of their graduates, and (iii) a social welfare perspective where the optimum depends on the assumed social welfare function. According to Becker (1973) and Chade et al. (2011), welfare is maximized by assigning the best students to the best universities as long as student and university quality are complements. Such a sorting of prospective students into universities exists in a two-sided market only if universities differ sufficiently in quality (Chade et al., 2011). Along this line, a hypothesis is that publishing quality indicators may enhance human capital and –

[1] For an evaluation of the German Bologna Process see Horstschräer and Sprietsma (2010).
[2] For analyses regarding the introduction of tuition fees in Germany see Dwenger et al. (2011) and Hübner (2009).

depending on the social welfare function – may also enhance a welfare maximizing assortative sorting.

An extensive empirical literature exists on the decision whether or not to attend university. However, this paper contributes to the more recent literature on *where* to attend university. Existing evidence in the field of university choice addresses both the influence of financial aid (e.g. Ehrenberg and Sherman, 1984; McPherson and Schapiro, 1991; Moore et al., 1991; Avery and Hoxby, 2003) and non-monetary factors (e.g. Toutkoushian, 2001; Mueller and Rockerbie, 2005; Griffith and Rask, 2007; Berkowitz and Hoekstra, 2011) on the matriculation (or application) decision. For the U.S., Weiler (1996) analyzes monetary and non-monetary factors influencing the matriculation decision of high-ability students and shows that attendance costs as well as non-monetary characteristics, such as university quality and reputation, are significant factors.

The influence of rankings on university choice, is explicitly studied by Monks and Ehrenberg (1999), Mueller and Rockerbie (2005) and Griffith and Rask (2007). Monks and Ehrenberg (1999) study the influence of the *U.S. News & World Report* rankings on admission at selective private institutions. They show that low-ranked universities accept a higher share of applicants, that more accepted applicants do not matriculate, and that matriculated students have lower SAT scores. Using Canadian application data, Mueller and Rockerbie (2005) find that an improvement in rank, in general, has a positive influence on the aggregated number of applications. The U.S. study by Griffith and Rask (2007) on an individual level also suggests that the matriculation decision of high-ability students is influenced by changes in rank and that rankings can affect individuals heterogeneously with respect to gender, nationality and ability. However, the Anglo-Saxon higher education system has always been more competitive than the comparatively homogeneous German higher education sector. Therefore, it is not obvious whether the international evidence is applicable to the German context.

The German studies by Büttner et al. (2003) and Helbig and Ulbricht (2010) analyze the influence of German university rankings on the number of matriculated students and the sorting of students according to ability. They show that rankings also seem to influence the matriculation decision in Germany. However, both German studies fail to disentangle the effect of the additional information provided by the rankings from the common knowledge regarding university attractiveness.

This paper contributes to the existing literature on university rankings by distinguishing the importance of different quality dimensions, while controlling for the common knowledge regarding university attractiveness. To my knowledge, this analysis is the first to provide evidence regarding the importance of different ranking dimensions. The international literature, so far, has been limited to the influence of the overall rank of an university. The German multidimensional ranking of the Center for Higher Education Development (CHE ranking), however, allows me to study several quality dimensions separately. The main quality dimensions published are research reputation, mentoring, faculty infrastructure as well as a recommendation by professors and students. An additional quality indicator studied is the excellence status awarded by the German government within an excellence competition. My results thus provide additional knowledge on which quality dimensions are (most) important for the university choice of prospective students.

A random utility model explaining the application decision by university and individual characteristics of the applicants is estimated using a conditional logit model. Due to the inclusion of university fixed effects, identification relies on the variation in rankings and excellence status over time. The estimated effects of the different quality indicators on university choice thus only comprise the response to changes in university quality as suggested by the indicators. The estimates do not reflect the time-constant common knowledge regarding university attractiveness, which is captured by the university fixed effects.

I use a very comprehensive, administrative data set provided by the German central agency ('ZVS') administering the application process for medical schools, which is subsequently called central clearinghouse.[3] The data set contains individual information on all applicants at German medical schools for the years 2002-2008. This data set offers two important advantages for my analysis. First, I can study the application rather than the matriculation decision. This is important as the application decision is less driven by supply constraints. Second, the individual nature of the data allows me to control for the distance between a student's hometown and each university in the choice set, which is shown to be a very important determinant of the application decision.

The results show that achieving excellence status increases the individual application probability by 19%. Hence, the excellence competition run by the German government significantly affects the university choice of high-ability students. Regarding the ranking indicators, a high rank with respect to students' satisfaction increases the application probability, and a low rank in mentoring, faculty infrastructure as well as in the indicator students' satisfaction lowers the probability to apply. The research oriented indicators of the German university ranking show no significant influence on the application probability. Research quality, nevertheless, proves to be a very important determinant for choosing a university. However, it seems to be common knowledge and therefore part of the general attractiveness of a university. In this case, the non-research indicators of the ranking provide more relevant information for the university choice of high-ability students than the research-oriented ranking indicators. Publishing multidimensional university rankings, thus, widens the basis of information for a well-informed university choice.

[3]In Germany, the university application process for the subjects medicine, pharmacology, veterinary medicine, dentistry, psychology and biology has been administered by a central agency called 'Zentralstelle zur Vergabe von Studienplätzen' (ZVS) during the observation period.

The remainder of the paper is structured as follows. In the next section, I give a more detailed overview on the institutional background of the German university ranking, the excellence initiative and the central admission procedure (Section 4.2). Subsequently, Section 4.3 describes the application data including first descriptive evidence, Section 4.4 explains the estimation strategy, and Section 4.5 presents the results. Section 4.6 concludes.

4.2 Institutional Background

The German higher education sector used to be quite homogeneous with respect to the quality of universities. The share of private institutions is traditionally very low. The public universities are administered and financed by the 16 German federal states. Unlike in the Anglo-Saxon system, no specific universities were considered as elite institutions, and no tuition fees existed until 2006. In general, only a registration fee of about 100 Euro had been levied each term by the universities. However, competition between universities has been encouraged lately. Besides the introduction of tuition fees and changes in the degree system due to the European homogenization, university rankings became publicly available and presumably also more important to prospective students due to encouraged competition.

German university rankings have been published in the media since the 1990's. For the first time, universities and prospective students could compare the quality regarding various quality dimensions between institutions. The university ranking of the Center for Higher Education Development (CHE ranking) is used for the analysis in this paper. It was first published in 1998 and is – similar to the *U.S. News & World Report* rankings for the U.S. – the most comprehensive and most detailed ranking of German higher education institutions. The first ranking of medical schools was published in 2003 in the weekly magazine "Stern", and the second ranking of 2006 was issued with the weekly newspaper "Die Zeit". Both newspapers are well-known and widely recognized outlets within Germany.[4]

Unlike the well-known rankings, such as the *U.S. News & World Report* ranking in the U.S. or the world-wide “The Times Higher Education Supplement” and the “Shanghai-Ranking of World Universities”, the German CHE ranking provides information on the subject level. Hence, rather university departments than universities as a whole are compared, which allows a much more detailed assessment. Another difference is that the CHE ranking does not publish league tables. The departments are instead merely sorted into a top, middle and bottom quality group. Most important for my analysis, the CHE ranking assesses various quality dimensions and publishes the results in all dimensions separately without aggregating them into an overall rank. This procedure avoids the controversial assignment of weighting factors to each indicator and enables prospective students to consider the quality dimensions most important to them.

All quality indicators rely either on facts collected on the university department level, on an evaluation by professors of the respective subject or on an assessment by current students. The ranking comprises all major subjects, and every subject is ranked in a three-year cycle. The main indicators in the publications of medical schools rankings – which are the ones used in my analysis – are:

- professors’ recommendation
- research reputation
- student-professor ratio
- number of clinic beds
- students’ satsifaction

[4]Other German rankings published during the observation period 2003-2008 are the ranking of the magazine “Focus” (2004,2007) and the magazine “Spiegel” (2004,2006). However, both rankings are not as comprehensive as the CHE ranking. Note also that there is a general discussion on the quality and methodology of university rankings. This paper, though, aims to assess in a first step whether quality indicators indeed influence students’ application choice. In case that rankings are indeed important for university choice, a thorough analysis of the rankings’ methodology is necessary.

For each of these measures, the published indicators only display whether the respective university is ranked into the top, middle or bottom group and whether that position has changed since the last ranking. To construct the indicator "professors' recommendation" ("research reputation"), professors are asked to name the top five universities in their field with respect to the overall university quality (research quality). Note, professors cannot recommend the university at which they are currently teaching. Universities named by more than a quarter of the professors are sorted into the top quality category and universities not mentioned at all form the bottom quality group. Information on the indicators "student-professor ratio" and the quantity of "clinic beds" are collected at the university department level. The "student-professor ratio" indicates the number of students per professor and the indicator "clinic beds" gives the quantity of beds per 100 students.[5] The departments are sorted into quality groups by calculating quantiles. Finally, the "students' satisfaction" regarding their current study program is evaluated. The top, middle and bottom quality groups for this indicator are constructed by calculating means and confidence intervals for the subject as a whole and for each department. If the mean of a department and the full range of its confidence interval is higher than the subjects' mean, the department is grouped into the top category. Is the departments' mean and its confidence interval below the subjects' mean, the department is assigned into the bottom quality group.

In addition to the introduction of university rankings, the excellence initiative run by the German Government in 2006 and 2007 has been another move towards competition. In principle, the initiative is a competition for extra funding between all German universities. It is not restricted to a special subject (e.g. medical studies) but addresses universities as a whole. The aim of the initiative was to strengthen German universities, to enhance their international competitiveness, and to promote

[5]The number of clinic beds of a medical school is relevant because it determines how much practical experience prospective students can expect.

the visibility of German top-level research. As part of the nationwide competition, additional funding has been given to the best proposals for (i) graduate schools promoting young academics, (ii) clusters of excellence, and (iii) institutional strategies of universities promoting top-level research. Successful graduate schools were granted approximately one million Euro per year, clusters of excellence in a specific field on average receive 6.5 million Euro per year, and universities with promising institutional strategies to promote top-level research were awarded about 21 million Euro in total. This funding is limited to a maximum of five years. Important to note is that especially the winning universities in the competition for strategies to promote excellent research have received high media attention and have been recognized as "excellence universities" since then.

Out of all 34 medical departments in Germany, six departments are located at universities which became "excellence universities". Munich was the only university with a medical department that received the excellence status in October 2006. In October 2007, the Universities of Aachen, Berlin, Freiburg, Göttingen and Heidelberg followed. As the results of the excellence competition were announced in October and the application deadline for medicine is in July, the excellence status became first relevant for the applicants of the University of Munich in 2007 and for all other "excellence universities" only in 2008. However, in January 2006 and 2007, the committee of the excellence initiative already announced which universities had been shortlisted.

The application procedure for universities in Germany differs by subject. For most subjects, prospective students address their applications directly to the universities. However, the application process is centrally administered by the central clearinghouse for some subjects. During the years 2002 to 2008, six subjects – medicine, pharmacology, veterinary medicine, dentistry, psychology and biology – had a centralized application and admission process. Within the central application process, every applicant may indicate a preference list of up to six universities and may apply within three different selection procedures. A competition by (i) the final secondary school grade, a procedure based on (ii) the duration that an applicant already is waiting for a university assignment, and (iii) a direct assessment by the universities are applied sequentially. If an applicant cannot be placed in procedure (i), his application is transferred to procedure (ii) and, if necessary, further to procedure (iii). Since 2004 (before 2004), 20% (51%) of the places to study have been assigned by the secondary school grade, 20% (25%) by the time of waiting, and 60% (24%) of the places have been allocated directly by the universities. The allocation process within these three procedures, though, has not changed over time.

Within procedure (i) the competition by secondary school grades, it is verified in a first step whether an applicant can be admitted at the university of his first preference. If there are more applicants than places to study, the secondary school grade is decisive. In case an applicant could not be placed at his first preference, the central clearinghouse examines the possibilities at the university listed as the second preference. However, all applicants who listed this university as their first preference are placed at this university first. This demonstrates the high importance of the first preference in the listing.[6] The competition by (ii) the time of waiting is very similar. Here, the time of waiting is decisive if there are more applicants than places. The criteria for (iii) the direct admission by universities differ by university, but in general, the secondary school grade is very important once again.

4.3 Data and Descriptives

The data set I use to assess whether the excellence initiative and the university rankings have influenced the application decision of prospective students contains all

[6] For a more detailed description of the centrally administered application process see Braun et al. (2010) and Braun and Dwenger (2009).

applicants at German universities in the centrally administered subjects within the years 2002 to 2008. A major advantage of this data set is that applications rather than matriculations are observed. The revealed preferences are, thus, less likely to be biased by supply side constraints.

Although the application data include all centrally administered subjects, I restrict the sample to applicants in the field of medical studies, which is by far the subject with the most applicants. Pharmacology, dentistry and veterinary medicine are excluded from the analysis as these subjects are only offered by very few universities resulting in a very limited choice set for prospective students. In the fields of psychology and biology, Bachelor and Master degrees were introduced, and since then, the application process is no longer centrally administered. Therefore, the analysis focuses solely on applicants for medical studies.

Similar to Dwenger et al. (2011), my estimations are based on the first university preference listed in the selection procedure using the secondary school grades. This is justified as the first preference is very important for the allocation process (see Section 4.2 and Braun et al. (2010)). In order to rule out any strategic preference listings, I only consider high-ability students who received the best possible grade (i.e. 1.0) in the final secondary school exam. This subgroup of students is not constrained by admission thresholds as the most restrictive threshold is having received the best final secondary school grade (1.0) and applying at the specific university with first priority. Hence, all applicants in my sample can state their true university preferences. The sample is further restricted to applications for the semester beginning in fall from 2003 to 2008 as only few universities accept applications for the semester beginning in spring and as the first ranking of medical schools was only published in 2003. In case someone applied for two subjects at a time (only possible until 2004), I only consider the application if medical studies is the first subject preference. Repeated

Table 4.1: Mean Statistics Disaggregated by Quality Indicators (2003-2008)

	Exc.	Prof. Rec.	Res. Rep.	Stud./Prof.	Clinic Beds	Stud. Sat.
Top Group/Exc.						
Appl./Uni (%)	12.63	13.63	13.41	3.02	9.55	3.10
Female (%)	66.83	63.46	63.30	70.66	65.57	71.93
N	*3,920*	*1,894*	*1,951*	*1,002*	*938*	*1,001*
Middle Group/Non-Exc.						
Appl./Uni (%)	6.89	3.48	3.46	9.29	8.00	10.85
Female (%)	66.63	69.24	68.51	65.57	66.71	65.10
N	*615*	*2,565*	*2,341*	*2,533*	*2,412*	*2,682*
Bottom Group						
Appl./Uni (%)	n.a.	0.74	2.20	8.50	6.17	3.16
Female (%)	n.a.	59.21	75.72	65.35	67.39	65.91
N	n.a.	*76*	*243*	*964*	*1,012*	*792*

Data Source: ZVS Data (2003-2008), own calculations. The number of observations deviates due to missings in the ranking variables. The indicator student-professor ratio (clinic beds, students' tip) is missing for five (one, two) universities. Appl./Uni: Average share of applicants at a university, Exc.: Excellence University, Prof. Rec.: Professors' Recommendation, Res. Rep.: Research Reputation, Stud./Prof.: Students per Professor, Stud. Sat.: Students' Satisfaction.

applications of applicants who were not assigned to a university in their first year of application are also excluded from the analysis.

Table 4.1 displays the average share of applications per university and the individual characteristics of the remaining 4,535 medicine applicants of the years 2003-2008. The descriptives are disaggregated by excellence status and the main quality indicators.[7] The average share of applicants is significantly higher for "excellence universities" and the top ranked departments in the categories "professors' recommendation" and "research reputation". The average share of applicants at an "excellence university" amounts to 12.63%, while the average share in the non-excellence group is only 6.89%. With respect to the other quality indicators "student-professor ratio", "clinic

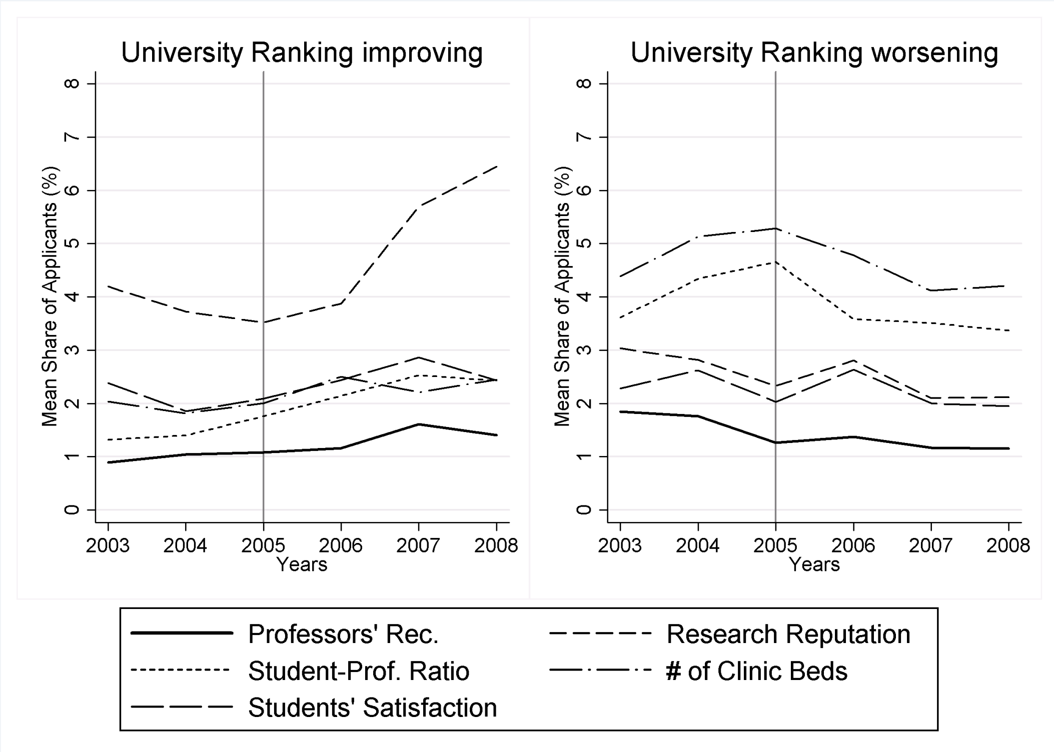
[7]In addition, Table A.4.1 in the Appendix provides a comprehensive overview on all 34 medical schools and their corresponding quality indicators.

beds" and "students' satisfaction", there is not such a clear sorting pattern. Nevertheless, the differences are also significant in a t-test. Examining the average share of female applicants in each quality group shows also heterogeneous results of the various ranking indicators. It seems that female applicants prefer universities that are highly ranked in the categories "student-professor ratio" and "students' satisfaction", whereas high ranks in "professors' recommendation" and "research reputation" are more important for male applicants. These differences are significant. Statistically non-significant, however, are the deviations in the ranking indicators "excellence university" and "clinic beds".

However, whether this selection pattern is induced by the quality indicators or by other confounding factors, e.g. overall prestige of a medical school, is not clear by simply looking at descriptive evidence. A mean comparison disaggregated by excellence status and year, for example, showed that "excellence universities" already had a high share of applicants before they received the official excellence status. Therefore, the question I want to answer is whether the share of applicants has increased even further due to the excellence initiative, and whether changes in the rankings over time influence the application decision.

Figure 4.1, therefore, depicts the mean share of applicants over time for the universities experiencing either an improving or a worsening in ranking indicators. Comparing mean application shares after the new ranking of 2006 with respect to different quality dimensions mainly indicates small gains for universities improving in rank. The indicator "research reputation" exhibits a strong increase in the average share of applications in 2007 and 2008 but not in 2006, when the new ranking was already available. Looking at the improving universities with respect to research in more detail shows that this increase is mainly driven by the University of Berlin becoming "excellence university" in 2008 (see Figure 4.2). Downgrading a university ranking in particular seems to lower the application probability if the ranking is worsening in the dimension

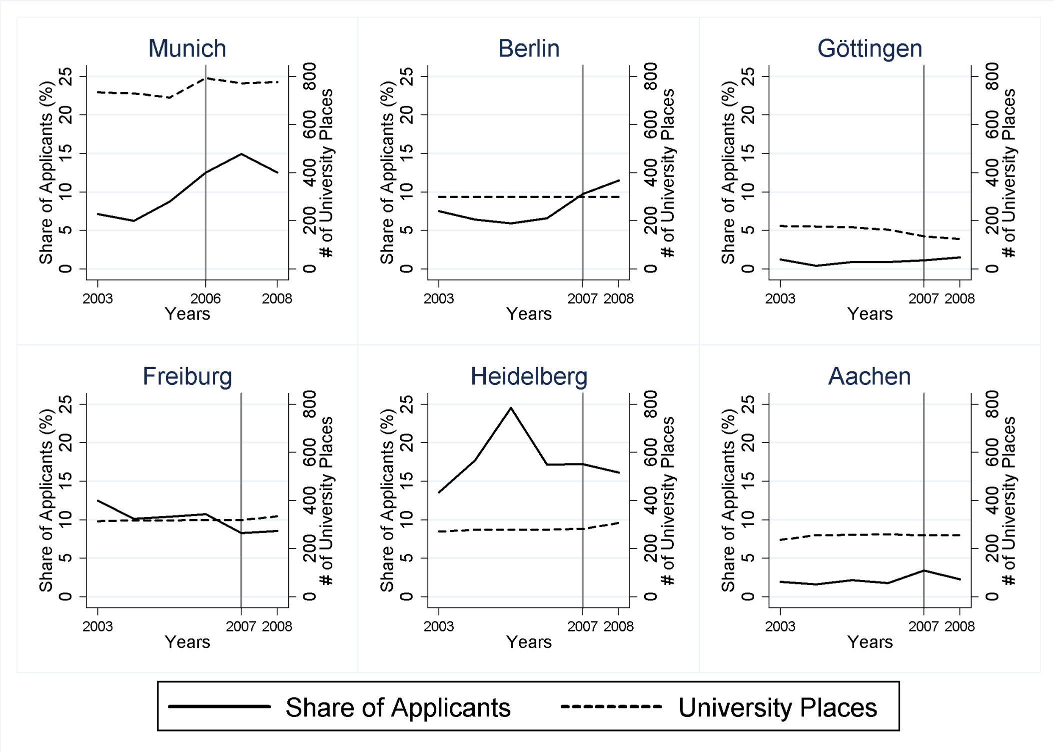
Figure 4.1: Share of Applicants at Universities with a Change in Ranking (2003-2008)



Data Source: ZVS Data 2003-2008, own calculations.

"student-professor ratio" or with respect to the number of "clinic beds". While the average share of applicants for universities with a decreasing rank in these dimensions increased until 2005, the share decreases after the publication of the second university ranking in 2006. Despite a worsening ranking in "research reputation" and "students' satisfaction", the average share of applicants for these universities is slightly increasing in 2006. On the one hand, this could hint at other quality dimensions being more important for university choice. On the other hand, these descriptive results could also be driven by other confounding factors. Interestingly, the indicator "professors' recommendation" is the most stable indicator. Universities improving or worsening in this dimension show the least changes in the average share of applicants.

Figure 4.2: Supply and Demand at "Excellence Universities" (2003-2008)



Data Source: ZVS Data 2003-2008, own calculations.

Regarding the supply and demand of university places at "excellence universities", Figure 4.2 depicts the share of applicants and the number of university places over time for each of the six medical schools located at "excellence universities". It provides descriptive evidence on whether the probability to apply at a university has increased in the course of the excellence initiative. The medical departments at the universities of Munich, Berlin, and too a lower extent, also the University of Aachen indeed experience an increase in the share of applications at the time of the excellence initiative. The share of applicants in Munich has been increasing already since 2005. The increase in Berlin and Aachen, however, sets off in 2007, which is the year they are shortlisted in the excellence initiative. The demand for the other universities seems to be stable or even decreases (University of Freiburg) in the years of the excellence initiative (2006, 2007 and 2008). The supply side, i.e. the number of university places, is constant over time for most universities. In Munich, though, the supply of university places slightly increases from 2005 to 2006. As there may also be other confounding factors – i.e. tuition fees were introduced in many federal states simultaneously to the excellence initiative – the descriptive evidence is not conclusive. Therefore, the next section explains the multivariate estimation strategy.

4.4 Estimation Strategy

In this section, I introduce the estimation strategy to estimate the influence of university rankings and the excellence competition on the application probability in a multivariate setting. Similar to Griffith and Rask (2007), the estimations are based on a random utility model (Equation 4.1). The utility U_{ij} of individual i applying at university j is explained by a deterministic part of applicant-university match specific characteristics (X_{ij}), university characteristics (Z_j) as well as by an unobserved random component ϵ_{ij}. Assuming that applicants reveal their true preferences and behave rationally, the observed choice of university maximizes their utility.

$$U_{ij} = \alpha X_{ij} + \beta Z_j + \epsilon_{ij} \tag{4.1}$$

Following Mc Fadden (1974), I estimate the choice model using a conditional logit approach. In contrast to a multinomial logit, this allows me to consider applicant-university-match-specific variables (e.g. distance from hometown). For the conditional logit model, the data needs to be in long form with j university observations for each applicant i. As there are 34 different universities offering medical studies, my data set expands from 4,535 individual observations to 154,190 applicant-university observations. Intuitively, the data set then contains the whole choice set of medical schools for each applicant. The outcome y_{ij} is a binary variable indicating the university the applicant actually has chosen to apply for. Thus, the estimation equation is specified as follows:

$$y_{ij} = \alpha_1 EXC_{ij} + \alpha_2 RANK1_{ij} + \alpha_3 RANK3_{ij} + \alpha_4 \tilde{X}_{ij} + \beta U_j + \gamma U_j \times D_{ij} + \epsilon_{ij} \quad (4.2)$$

The model incorporates EXC_{ij}, $RANK1_{ij}$ and $RANK3_{ij}$ as variables of interest. EXC_{ij} is a binary variable being equal to one if university j has received an excellence status at the time individual i is applying. $RANK1_{ij}$ ($RANK3_{ij}$) is a vector of ranking outcomes indicating whether university j is ranked in the top (bottom) group of a specific quality measure. Hence, the ranking indicators for being in the top (bottom) group are estimated in reference to the group of medium quality. $\tilde{X}_{ij}$ represents all applicant-university – respectively also time-university[8] – specific variables, which are distance to university, distance squared, a binary variable indicating the introduction of tuition fees and the number of supplied university places. A set of dummy variables U_j controls for university characteristics which are constant over all individuals and over time – e.g. university quality that is common knowledge.[9] In other words, U_j represents university fixed effects that account for the time-constant common knowledge regarding university attractiveness. By additionally interacting the university fixed effects with the distance D_{ij} of student's i hometown to university j, I also take into account that students may be willing to move further away for some

[8]Note that variables varying over time also vary between individuals as repeated cross-sections are pooled over six years.

[9]Also city-specific characteristics, e.g. costs and quality of living, are captured by U_j if they are constant over time.

universities but not for others. Hence, the importance of distance to university does not only differ between individuals but also between universities.

The variation used for conditional logit estimation is within a student's choice set. Hence, the estimation approach links the binary outcome variable indicating the chosen university to the university- and applicant-university-specific attributes and estimates the coefficients that maximize the probability for the chosen category out of the student's choice set. In order to correct for correlations between the error terms within an individual's choice set, I cluster the standard errors by individuals.

Due to the university fixed effects U_j, the identification of the variables of interest – excellence status and ranking indicators – solely relies on variation over time, i.e. the introduction of the excellence competition and changes in the ranking between 2003 and 2006. Hence, unlike Büttner et al. (2003) and Helbig and Ulbricht (2010), who estimate the effect of rankings without a university fixed effect, I can disentangle the common knowledge regarding prestige and attractiveness of a medical department from changes in the different quality indicators. Table 4.2 depicts the variation over time due to changes in the ranking indicators from 2003 to 2006 and the introduction of the excellence competition respectively. I observe between 2 and 10 universities out of the 34 universities (5.88% - 29.41%) for which the according ranking indicator changes between 2003 and 2006. Thus, there is reasonable variation over time that I can exploit for my identification strategy.

Moreover, the quality indicators studied are most likely exogenous to the applicants' university choice. Nevertheless, endogeneity concerns could emerge with respect to the indicator "students' satisfaction". This indicator represents how satisfied current students are with their studies overall at a specific university. Peers of prospective students who study medicine already may influence the ranking indicator and, at the same time, directly the university choice of prospective students. However, endo-

Table 4.2: Number of Universities with a Change in Excellence Status or in a CHE Ranking Indicator over Time

	Top Group / Excellence		Bottom Group	
	# Universities	%	# Universities	%
Excellence Status	6	17.65	n.a.	n.a.
Professors' Rec.	2	5.88	5	14.71
Research Reputation	5	14.71	8	23.53
Student-Prof. Ratio	7	20.59	10	29.41
# Clinic Beds	7	20.59	7	20.59
Students' Satisfaction	5	14.71	9	26.47

Data Source: CHE ranking data (2003 and 2006), own calculations.

geneity is a minor concern for the indicators evaluated by the professors ("professors' recommendation" and "research reputation") and even more so for the hard facts "student-professor ratio" and the number of "clinic beds".

A common concern when applying a conditional logit model is the independence of irrelevant alternatives (IIA) assumption. The assumption requires the relative risk of two alternatives to be unaffected by the inclusion or exclusion of other alternatives. In my case, an exclusion or change in quality of university A should not affect the relative risk of applying at university B versus applying at university C. I use a standard Hausman-type test (Hausman and McFadden, 1984) to check this assumption. The results suggest that my application of conditional logit estimation is not rejected by the Hausman test.

4.5 Results

This section presents the results of the conditional logit estimations that indicate if and how prospective high-ability students are influenced by different quality indicators when choosing a university. The estimated effects are displayed as odds ratios.[10] Odds ratios can be interpreted as a percentage change in the outcome variable induced by a unit change in the variable of interest holding all other variables constant. More formally, the odds ratio for variable x_{ij} is a proportional change in the odds of applicant i applying for university j for a unit increase of x_{ij} all else being equal. An effect above (below) one indicates an increase (decrease) in the odds to apply.

Table 4.3 depicts the odds ratios for the different quality indicators of the ranking and the excellence initiative based on different specifications. According to the final specification (V), receiving excellence status increases the probability to apply by 19.3%. This translates to an increase in application share for the treated "excellence universities" by about 2.44 percentage points.[11] In specification (VI), I add two variables to account for the shortlist announcement in 2006 and 2007: a binary variable being one if a university was on the shortlist in 2006 or 2007 and another binary variable indicating a failed excellence application. The indicator for being shortlisted depicts a positively significant effect suggesting an increase in the application probability by 28.9%, while the application probability for a failed university does not change significantly. Thus, I observe an announcement effect, which is a typical example of an Ashenfelter's Dip (Ashenfelter, 1978). The effect of being one of the universities on the shortlist even exceeds the estimated effect for the winners of the excellence initiative. This seems plausible as the media attention during this phase of the initiative was at its highest.

Regarding the different quality dimensions of the ranking, only the indicator "students' satisfaction" increases the probability to apply at a highly ranked univer-

[10] Odds ratios are calculated as $e^{\hat{\beta}}$.

[11] The effect in percentage points is calculated by multiplying the average share of applications at "excellence universities" (12.63%, see Table 4.1) with the percentage change indicated by the odds ratios (12.63% $\times$ 0.193% = 2.44 percentage points). This calculation corresponds to the idea of an average treatment effect on the treated.

Table 4.3: Effect of the Quality Indicators on the Application Probability (Odds Ratios)

	(I)	(II)	(III)	(IV)	(V)	(VI)
Excellence	1.122*	1.264***	1.329***	1.250**	1.193**	1.377***
	(.068)	(.097)	(.110)	(.111)	(.102)	(.150)
Exc. Shortlist						1.289***
						(.127)
Exc. Failure						.933
						(.164)
Top Rank						
Prof. Rec.	2.918***	3.102***	3.305***	.948	.982	.933
	(.162)	(.236)	(.254)	(.189)	(.199)	(.207)
Res. Rep.	2.537***	3.007***	2.826***	1.313**	1.178	1.128
	(.146)	(.234)	(.220)	(.164)	(.124)	(.120)
Stud./Prof.	1.130**	1.064	1.071	1.113	1.113	1.066
	(.067)	(.070)	(.072)	(.122)	(.121)	(.118)
Clinic Beds	1.194***	1.137**	1.108*	.948	.920	.959
	(.059)	(.061)	(.060)	(.085)	(.084)	(.089)
Stud. Satisf.	1.172**	1.359***	1.368***	1.362**	1.355**	1.257*
	(.085)	(.109)	(.110)	(.169)	(.170)	(.173)
Bottom Rank						
Prof. Rec.	.344***	.275***	.301***	.761	.830	.870
	(.042)	(.033)	(.036)	(.167)	(.185)	(.196)
Res. Rep.	.694***	.769***	.696***	.818	.832	.919
	(.053)	(.057)	(.054)	(.107)	(.117)	(.132)
Stud./Prof.	.863***	.628***	.649***	.702***	.698***	.674***
	(.037)	(.031)	(.034)	(.067)	(.066)	(.065)
Clinic Beds	1.410***	1.311***	1.290***	.843	.804**	.732***
	(.069)	(.073)	(.071)	(.095)	(.089)	(.084)
Stud. Satisf.	.895**	.861***	.869***	.828*	.801**	.790**
	(.039)	(.044)	(.047)	(.081)	(.076)	(.076)
Controls						
Distance		.976***	.976***	.976***	.983***	.983***
		(.000)	(.000)	(.000)	(.001)	(.001)
Distance^2		1.000***	1.000***	1.000***	1.000***	1.000***
		(.000)	(.000)	(.000)	(.000)	(.000)
Tuition Fees			.767***	.783**	.786**	.809**
			(.055)	(.076)	(.077)	(.079)
Uni Places			1.000	1.002**	1.001**	1.001**
			(.000)	(.001)	(.001)	(.001)
Uni FE				yes	yes	yes
Uni x Distance					yes	yes
Pseudo R^2	0.1145	0.4051	0.4055	0.4319	0.4477	0.4479
# Individuals			4,535			
N			154,190			

Data Source: ZVS Data (2003-2008), own calculations; additional missing dummies are included for the quality indicators students' tip, student-professor ratio and the number of clinic beds; clustered standard errors in parentheses; */**/*** indicate significance at the 10/5/1 percent level.

sity (+35.5%). The bottom rank variables for the "student-professor ratio", the number of "clinic beds" and the "students' satisfaction" suggest that prospective students try to avoid universities ranked poorly in these quality dimensions. The odds ratios manifest a significant decrease in the probability to apply by 21 % to 33 %. The ranking dimensions "professors' recommendation" and "research reputation" do not significantly influence the university choice of prospective students in the final specification. Hence, the non-research indicators mentoring, infrastructure and students' satisfaction seem to provide more important information for the prospective students.

Bearing in mind that I look at the university choice of high-ability students, this might seem counterintuitive. In fact, the mean statistics in Table 4.1 show a clear sorting along the indicators "professors' recommendation" and "research reputation" with higher shares of applications in the top quality group. Hence, research quality is indeed very important to the applicants. A possible explanation for the insignificant research indicator is that the information on research quality is common knowledge even without the university ranking. The publications of ranking indicators with respect to research quality then contain only little new information. Furthermore, if high-ability students only apply for the universities which are always ranked top in the research dimension, an improving research quality of another university is unlikely to affect their university choice. This interpretation is supported by the data as the significant influence of both research oriented indicators disappears when I include university fixed effects and their interaction with distance to university, which capture the commonly known and time-constant attractiveness of a university (see specifications (III), (IV) and (V)).

In addition to the university fixed effects and their interactions with distance, I further control for the distance between each university and a student's hometown, the distance squared, the introduction of tuition fees from 2006 onwards and the number of university places supplied. Most importantly, the individually calculated distance to each university and its square explains the university choice to a very large extent. While the Pseudo-R^2 for specification (I) – containing only the university quality variables – amounts to 0.1145, adding the distance variables rises the explanatory power to 0.4051 (specification (II)). Hence, distance to a university overall is the most important determinant of university choice even for the high-ability students in Germany. In the main model, each kilometer a university is further apart lowers the probability to apply by 1.7 %. Considering that the average distance between the nearest and the second nearest university amounts to about 38 kilometers, German applicants are fairly immobile. As to be expected, tuition fees decrease the application probability by about 21 %, and per 10 additionally provided university places the application probability rises by 1 %.

All in all, the rankings seem to provide high-ability students mainly with information concerning the non-academic quality. They use the additional information of the ranking primarily to avoid universities with the worst quality in mentoring, faculty infrastructure and the student assessment. However, receiving excellence status - which is also closely related to research quality – increases the application probability significantly. Therefore, the excellence competition may be regarded as an additional quality indicator providing new information that exceed the commonly known university quality.

Regarding the IIA assumption, I use a Hausman test to check whether the assumption holds and thus whether my application of a conditional logit model is appropriate. Excluding one university at a time while estimating the university choice model (specification (V)), the Hausman test mainly confirms the independence of irrelevant alternatives. The test fails for only 3 out of 33 sequentially excluded universities at a significance level of 1 %.

Table 4.4: Heterogeneous Effects of Quality Indicators by Gender (Odds Ratios)

	Women		Men	
Excellence	1.259**	1.553***	1.113	1.167
	(.131)	(.210)	(.163)	(.218)
Exc. Shortlist		1.420***		1.010
		(.173)		(.188)
Exc. Failure		.989		.915
		(.216)		(.274)
Top Rank				
Prof. Rec.	1.117	1.099	.751	.709
	(.276)	(.300)	(.271)	(.280)
Res. Rep.	1.128	1.061	1.315	1.291
	(.149)	(.143)	(.232)	(.230)
Stud./Prof.	1.035	.994	1.275	1.238
	(.134)	(.132)	(.262)	(.258)
Clinic Beds	.917	.968	.911	.927
	(.100)	(.107)	(.156)	(.160)
Stud. Satisf.	1.558***	1.378*	1.030	1.019
	(.232)	(.226)	(.254)	(.272)
Bottom Rank				
Prof. Rec.	.744	.808	1.159	1.170
	(.206)	(.227)	(446)	(.451)
Res. Rep.	.950	1.087	.562**	.584*
	(.158)	(.186)	(.152)	(.161)
Stud./Prof.	.768**	.737***	.583***	.574***
	(.088)	(.085)	(.101)	(.100)
Clinic Beds	.674***	.590***	1.142	1.101
	(.091)	(.083)	(.221)	(.220)
Stud. Satisf.	.844*	.831	.731*	.726**
	(.101)	(.100)	(.118)	(.118)
Pseudo R^2	0.4407	0.4411	0.4742	0.4742
# Individuals	3,023		1,512	
N	102,782		51,408	

Data Source: ZVS Data (2003-2008), own calculations; covariates: distance, distance^2, tuition fees and uni places; additional missing dummies are included for the quality indicators students' tip, student-professor ratio and the number of clinic beds; clustered standard errors in parentheses; */**/*** indicate significance at the 10/5/1 percent level.

To analyze the results of the excellence and ranking indicators in more detail, Table 4.4 presents the heterogeneous effects with respect to the applicant's gender. The results for women show the same significant results as in the full sample. Achieving excellence status and a good evaluation by current students raise the application probability, while low quality in mentoring, faculty infrastructure and the student assessment yields a decreasing application probability. For men, however, the picture is different. Their university choice does not seem to be influenced by the excellence initiative. Furthermore, I do not find a significantly positive effect for any top quality ranking indicator. Similar to the estimates for women, men have a lower application probability if the university provides an unfavorable student-professor ratio or if current students evaluate it poorly. A low rank with respect to research reputation also reduces the odds to apply for men, while female students do not react to this indicator.

Note that the sample of men is by half smaller than the female sample. Some estimates, thus, can also be insignificant due to the smaller sample size. Using a 50% random sample of the females for estimation, which sample size then is comparable to the men's sample, only the bottom rank indicators "student-professor ratio", the number of "clinic beds" and the "students' satisfaction" remain significant (see Table A.4.2).

As a robustness check, I estimate a pseudo introduction of the excellence competition in 2004 and 2005 and a pseudo change in the university ranking in 2005 (see Table 4.5). If the applied university choice model is appropriate, the quality indicators should not affect the applicants' decision at a point in time before the indicators became public. Therefore, I create a dummy variable indicating that the "excellence universities" received the excellence status already in 2004 and 2005 respectively, and I assign the ranking indicators of the second ranking, published in 2006, already to the corresponding universities in the year 2005.

Restricting the observation period to the years 2003 - 2005 and estimating the main models (specifications (V) and (VI) in Table 4.3) yields mainly non-significant results for the achieving excellence status as well as for being shortlisted or having failed to obtain excellence status. In the full sample, only the bottom rank indicator for the number of clinic beds is negatively related to the application probability. This effect is only significant at the 10 % level. Compared to the main estimations in Table 4.3, the effect lost significance.

Estimations on the female sample yield the same weakly significant correlation between poor infrastructural quality and the application probability. The specification incorporating only the main excellence indicator also shows a significant increase in the probability to apply for “excellence universities” although the status “excellence university” has not been awarded at this point in time. However, the effect loses its significance in the specification incorporating dummy variables for the universities being shortlisted and having failed within the excellence initiative. Estimations using the sample of men do not show any significant results. As mentioned above, smaller sample sizes may be partly responsible for the less significant results. These pseudo estimations are only a crude check of robustness as they are based on only one post-reform year of observation. Nevertheless and despite the few remaining significant effects, the robustness check in general supports my results and suggests that my estimates indeed reflect the influence of changes in quality indicators on the university choice of high-ability students.

Table 4.5: Pseudo Introduction of Excellence Competition and Change in Rankings (Odds Ratios)

	Full Sample		Women		Men	
Excellence	1.266	1.129	1.481**	1.286	.999	.825
	(.192)	(.388)	(.292)	(.557)	(.245)	(.479)
Exc. Shortlist		.886		.859		.818
		(.290)		(.356)		(.451)
Exc. Failure		.783		.674		.887
		(.288)		(.312)		(.572)
Top Rank						
Prof. Rec.	1.306	1.267	1.189	1.112	1.504	1.540
	(.381)	(.379)	(.427)	(.415)	(.779)	(.802)
Res. Rep.	.875	.871	.845	.839	.943	.943
	(.137)	(.137)	(.168)	(.166)	(.253)	(.253)
Stud./Prof.	1.199	1.177	1.137	1.093	1.188	1.199
	(.213)	(.210)	(.246)	(.239)	(.395)	(.400)
Clinic Beds	.874	.891	.940	.977	.746	.749
	(.128)	(.134)	(.169)	(.181)	(.195)	(.198)
Stud. Satisf.	.997	1.000	.964	.975	1.133	1.112
	(.204)	(.206)	(.242)	(.246)	(.434)	(.428)
Bottom Rank						
Prof. Rec.	1.063	1.109	1.388	1.509	.529	.530
	(.370)	(.393)	(.588)	(.661)	(.361)	(.364)
Res. Rep.	.704	.713	.765	.789	.678	.680
	(.157)	(.160)	(.210)	(.218)	(.269)	(.270)
Stud./Prof.	1.040	1.043	.963	.968	1.211	1.214
	(.137)	(.138)	(.155)	(.156)	(.299)	(.300)
Clinic Beds	.734*	.727*	.687*	.673*	.691	.690
	(.121)	(.120)	(.150)	(.147)	(.191)	(.192)
Stud. Satisf.	.903	.913	.826	.843	.981	.983
	(.135)	(.136)	(.158)	(.161)	(.246)	(.247)
Pseudo R^2	0.4812	0.4812	0.4828	0.4829	0.5007	0.5007
# Individuals	1,969		1,266		703	
N	66,946		43,044		23,902	

Data Source: ZVS Data (2003-2008), own calculations; covariates: distance, distance^2, tuition fees and uni places; additional missing dummies are included for the quality indicators students' tip, student-professor ratio and the number of clinic beds; clustered standard errors in parentheses; */**/*** indicate significance at the 10/5/1 percent level.

4.6 Conclusion

In this paper, I distinguish the importance of different university ranking dimensions for the university choice of high-ability students. Quality indicators considered are the “professors’ recommendation”, “research reputation”, “student-professor ratio”, the number of “clinic beds” and “students’ satisfaction”. Furthermore, I provide an evaluation of an excellence competition run by the German government awarding universities with an outstanding future concept for top-level research. Using administrative application data for all German medical schools, I estimate a random utility model of the high-ability students’ application choice in a conditional logit setting. Identification relies on the variation over time induced by changes in the ranking indicators between the first publication in 2003 and the second in 2006 as well as by the introduction of the excellence initiative in 2006 and 2007. This allows me to distinguish the effect of changes in the different quality indicators from the general attractiveness of a university.

The evaluation of the excellence initiative shows that, in course of the competition, the share of applicants increased at the winning universities, which are today known as “excellence universities”. On average, achieving excellence status increases the application probability by 19%, which relates for the “excellence universities” to an increase in applications of about 2.44 percentage points. Hence, the excellence competition and the accompanying media attention provide additional information that exceed the common knowledge on university attractiveness and thus affect the university choice of high-ability students.

The results regarding the different ranking indicators suggest that the non-research dimensions “student-professor ratio”, the number of “clinic beds” and the “students’ satisfaction” rather than the research-oriented indicators widen the basis of information for choosing a university. This does not by any means suggest that high-ability students in Germany do not care about research quality. In fact, research quality affects their university choice significantly. However, the research quality of German medical schools is rather recognized as part of the common knowledge regarding university attractiveness and, as such, is captured by the incorporated university fixed effects. Hence, the research dimension of the ranking does not provide the high-ability applicants with any new information, while the indicators regarding mentoring, faculty infrastructure and the student assessment do. The ranking indicators are thus, especially in the non-research dimensions, in action where they add new information to the common knowledge of universities' research reputation.

Providing information on all quality dimensions separately instead of publishing university rankings in aggregated league tables can thus be useful to support a well-informed university choice. This in turn could reduce drop-out rates, increase human capital production and – depending on the social welfare function – also increase overall welfare. An important prerequisite for the ranking to improve the applicant-university match, though, is that the quality indicators reflect real quality differences. Therefore, the discussions about ranking methodology are important for assessing the benefits of university rankings (e.g. see Cremonini et al., 2008).

Another positive aspect of publishing multidimensional rankings is that the universities well-known for their top level research also need to guarantee a good standard with respect to the non-research ranking indicators if they want to attract high-ability students. Top research institutes, therefore, cannot completely specialize in research and fully neglect e.g. mentoring quality as a low rank in the non-research indicators also lowers the application probability of high-ability students. Hence, multidimensional rankings could induce incentives for the top research institutes also to invest in the non-research quality dimensions.

When interpreting my results, it is important to keep in mind that the distance between a student's hometown and the university remains the most powerful determinant of university choice in Germany. Quality indicators, as shown, affect university choice, especially if they add new information to the common knowledge of universities' research reputation but, due to the immobility of students, only to a moderate extent. Either German students are simply reluctant to move far away from their hometown, even if they benefitted from attending a high-quality university, or they still recognize the German medical schools as a group of homogeneous quality such that there is no need for them to apply at universities further away from their hometown.

A factor limiting the generalization of my analysis is that I focus on the university decision of high-ability students. High-ability students are probably intrinsically motivated to a high degree and, therefore, are personally very interested in attending one of the best universities. Moreover, students with the best grade in their final secondary school exam are not constrained by admission thresholds. Therefore, the influence of the different ranking indicators on average students can differ from my results. The dimensions not related to research could be even more important for average students as they, for example, might expect to need more and better mentoring. Another concern is that medical students could be different from students of other subjects. In that case, it is unclear whether the effects of the different quality indicators can be translated to the behavior of university applicants in general. This is even more so as the German job market in the field of medicine is not as competitive as in other fields. To signal one's quality on the labor market by the quality of the attended university, therefore, could be even more important in other fields than medicine.

Overall, by analyzing the importance of different quality indicators for choosing a university, I show not only that university rankings do affect high-ability students in the application process but also that the influence of the ranking indicators differ with respect to the quality dimensions. Therefore, publishing multidimensional university rankings widens the basis of information for prospective students. University applicants can decide which quality dimensions are most important to them and, subsequently, may apply with a higher probability at the university that fits them best.

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Appendix

Table A.4.1: Excellence Status and Ranking Indicators by University (2003 vs. 2006)

University of ...	Exc.	Prof. Rec. '03	Prof. Rec. '06	Res. Rep. '03	Res. Rep. '06	Stud./Prof. '03	Stud./Prof. '06	Clinic Beds '03	Clinic Beds '06	Stud. Sat. '03	Stud. Sat. '06
Aachen	2007	2	2	2	2	3	1	2	2	2	1
Berlin	2007	2	2	2	1	2	2	3	3	2	2
Bochum	no	2	3	2	3	3	3	x	1	3	3
Bonn	no	2	2	2	2	2	3	2	2	3	3
Dresden	no	2	2	2	2	1	2	1	2	1	2
Düsseldorf	no	2	2	2	2	2	3	2	3	x	3
Erlangen-Nürnb.	no	2	2	2	2	1	1	2	x	2	2
Essen	no	2	3	2	2	2	1	2	2	2	1
Frankfurt/Main	no	2	2	2	2	2	3	2	2	3	2
Freiburg	2007	1	1	1	2	2	2	2	3	2	2
Gießen	no	2	3	2	3	2	2	3	2	2	2
Göttingen	2007	2	2	2	2	3	3	3	3	2	3
Greifswald	no	2	2	2	3	1	1	1	1	1	1
Halle	no	2	2	2	3	1	1	1	2	1	1
Hamburg	no	2	2	2	2	1	3	x	x	3	3
Hannover	no	2	2	2	2	2	3	3	3	3	2
Heidelberg	2007	1	1	1	1	2	3	1	2	2	2
Heidelb.-Mannh.	no	2	1	2	1	3	x	2	2	2	x
Jena	no	2	2	2	3	1	1	1	2	1	1
Kiel	no	2	3	2	3	2	2	2	3	3	2
Cologne	no	2	2	2	2	3	3	3	2	3	3
Leipzig	no	2	2	2	2	2	2	3	3	2	2
Lübeck	no	2	2	2	2	3	1	2	1	1	1
Magdeburg	no	2	2	2	2	1	1	1	1	1	1
Mainz	no	2	2	2	2	3	3	2	2	3	3
Marburg	no	2	2	2	2	2	2	2	x	3	2
Munich	2006	1	1	1	1	2	2	2	2	3	2
Münster	no	2	2	2	2	3	1	3	2	1	1
Regensburg	no	2	2	2	2	1	1	1	2	1	1
Rostock	no	2	2	2	3	2	2	1	1	1	2
Saarbrücken	no	2	3	2	3	3	2	x	1	2	3
Tübingen	no	1	2	1	2	2	2	2	2	2	3
Ulm	no	2	2	2	2	2	2	2	3	3	2
Würzburg	no	2	2	1	2	1	2	2	1	2	1

Data Source: CHE Ranking 2003 and 2006; 1(2,3): top (middle, bottom) ranking group; x: indicator missing; Exc.: Excellence status; Prof. Rec.: Professors' Recommendation; Res. Rep.: Research Reputation evaluated by Professors; Stud./Prof.: Student-professor ratio; Clinic Beds: Number of clinic beds; Stud. Sat.: Students' Satisfaction.

Table A.4.2: Heterogeneous Effects using a 50 % Random Sample of Females (Odds Ratios)

	Women	
Excellence	1.261	1.449*
	(.188)	(.280)
Exc. Shortlist		1.278
		(.218)
Exc. Failure		.911
		(.295)
Top Rank		
Prof. Rec.	1.113	1.046
	(.388)	(.404)
Res. Rep.	.953	.914
	(.171)	(.166)
Stud./Prof.	1.047	1.009
	(.193)	(.195)
Clinic Beds	.831	.868
	(.129)	(.136)
Stud. Satisf.	1.297	1.197
	(.273)	(.282)
Bottom Rank		
Prof. Rec.	.659	.704
	(.261)	(.281)
Res. Rep.	1.102	1.222
	(.258)	(.298)
Stud./Prof.	.745*	.722**
	(.120)	(.118)
Clinic Beds	.669**	.609***
	(.125)	(.117)
Stud. Satisf.	.650**	.639***
	(.110)	(.110)
Pseudo R^2	0.4460	0.4463
# Individuals	3,023	
N	102,782	

Data Source: ZVS Data (2003-2008), own calculations; covariates: distance, distance^2, tuition fees and uni places; additional missing dummies are included for the quality signals students' tip, student-professor ratio and the number of clinic beds; clustered standard errors in parentheses; */**/*** indicate significance at the 10/5/1 percent level.

5 Decentralizing University Admission – Evidence From a Natural Experiment *

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Abstract

In this paper, I study the decentralization of university admission as a natural experiment in university admission. Is the centralized or decentralized procedure better suited to match prospective students to universities? Using a differences-in-differences approach, I estimate the effect of decentralizing admission to German law schools on the matching efficiency (number of first-year students/unassigned university places) and the matching quality (drop-out rates). My evaluation study uses administrative data on all students within Germany and complements the prominent theoretical literature on college admission. The results show that the matching efficiency increased in course of the decentralization. This increase is mainly driven by enabling law schools to abolish admission restrictions. The matching quality is not significantly affected by the decentralization process but suggests that abolishing admission restrictions could be associated with increasing drop-out rates.

Keywords: Higher education, college admission problem, university admission

JEL: I21, I23, C23

5.1 Introduction

University admission can be either organized by a central clearinghouse or in a decentralized process by the universities themselves. Prospective students in the U.S. as well as graduate students in the UK, for example, apply directly at their preferred universities. All undergraduate students in the UK, however, need to apply with the central authority "UCAS" (Universities & Colleges Admission Service) and merely indicate a preference list of universities. Historically, decentralized matching procedures were often object to market failure and were therefore replaced by centralized mechanisms. A famous example being the introduction of a central clearinghouse in the early 1950s for the entry-level labor market for American physicians (Roth and Peranson, 1999).

Similarly in Germany, a central clearinghouse ('ZVS') was established in 1973 to admit students in subjects with scarce university places as numbers of applicants were increasing. However, the admission procedure for some subjects – e.g. for law studies in 2002 – was decentralized again later on. Besides decreasing applications, another reason for this turn was to allow for more competition between universities. Decentralizing university admission comprised two major changes in the admission procedure. First, prospective students apply directly at the universities and are subsequently directly admitted by the universities without the coordination of a central clearinghouse. Second, universities themselves decide on the admission criteria they apply. In fact, some universities abolished all admission restrictions in course of the decentralization, which enabled students to directly enroll into their programs.

In this paper, I exploit the natural experiment of a change from centralized towards decentralized admission to German law schools in order to evaluate the centralized and decentralized matching of students to universities. Using German administrative student data and applying a differences-in-differences strategy, I study the student-university matching with respect to the outcomes (i) the number of first-year students, (ii) the number of unassigned university places, and (iii) the drop-out rates. As admission to all law schools except the ones in the largest German federal state of North Rhine-Westphalia has been decentralized, I use the regional variation over time between law schools in and outside of North Rhine-Westphalia for identification. In addition, I employ medical schools as a second control group because admission to medical schools has been centrally administered over the entire observation period. Furthermore, my analyses consider both changes induced by the decentralization process the abolishment of the central clearinghouse and of admission restrictions.

On the one hand, a decentralized admission process may be superior to a centralized process as the universities arguably have the most comprehensive information to decide on their student body. On the other hand, decentralized admission may increase uncertainty in the process as students need to send out multiple applications and universities need to overbook their places. The decentralized procedure, thus, may lead to (too) late assignment, late enrollment, and unassigned university places (e.g. Roth and Xing, 1994; Müller, 2007, 2009). Furthermore, if universities are overburdened with the admission responsibilities, they may choose the wrong applicants resulting in less human-capital production or higher drop-out rates. Since no admission procedure has been identified as being clearly superior so far, discussions on the optimal university admission process are currently ongoing in Germany as well as on an international level.[1]

The prominent theoretical literature on the “College Admission Problem” (Gale and Shapley, 1962) studies different centralized matching mechanisms (a special set of rules for assigning students to universities) with respect to their matching efficiency. The centralized matching mechanisms are based on preference lists of students over

[1]See the discussion in the UK on reforming the central admission authority ‘UCAS’ (UCAS, 2011).

universities as well as on the preferences of universities over students. The literature building upon the seminal paper by Gale and Shapley (1962) identifies two competing mechanisms: the college proposing deferred-acceptance mechanism, which is optimal with respect to the colleges' preferences, and the student proposing deferred-acceptance mechanism, which is student-optimal (Kelso and Crawford, 1982; Roth, 1984a). Within the college (student) proposing version, students (colleges) are able to hold their so far most preferred offer without accepting it right away. Colleges, however, have an incentive to state strategic preferences within the college-optimal mechanism (Roth, 1985). [2] Within the related field of school choice, Abdulkadiroglu and Sönmez (2003) study the theoretical properties of the "Boston Student Assignment Mechanism". This priority matching mechanism tries to match all students to their school of first choice. However, if a student cannot be assigned at his first school choice, it is unlikely that he is placed at his second preference as all places may already be taken by students who have been placed according to their first choice. Therefore, students and parents strategically decide on the first choice within the Boston matching mechanism. All in all, the theoretical literature on centralized matching mechanisms points out that well-defined matching mechanisms exist but may be sensitive to strategic behavior.

The more recent theoretical literature on decentralized matching is less comprehensive. Roth and Vate (1990, 1991) are the first to extend the theoretical college admission literature to decentralized systems by allowing some randomness within the matching process. The literature shows that decentralized systems may produce efficient matchings but also describes situations in which inefficiencies can occur (Roth and Xing, 1994; Pais, 2008b,a; Haeringer and Wooders, 2011). For example, Roth

[2] Further evidence on the college admission problem is provided by e.g. Roth (1984b); Roth and Sotomayor (1989); Roth (1991); Kara and Sönmez (1997); Alcalde and Romero-Medina (2005); Klaus and Klijn (2006). For an introduction to the literature see Roth and Sotomayor (1992).

and Xing (1994) report on imperfections that arise due to the timing of transactions within decentralized markets.

Despite the vast theoretical literature on college admission, empirical evidence is very limited. Portela et al. (2008) describe the centralized student allocation process in Portugal and find a mismatch between demand and supply with some universities not being able to fill their places. Related to college admission, Krishna and Ünver (2008) compare two centrally administered matching mechanism for course allocation at an American business school. Using a field and a laboratory experiment, they show that efficiency can be improved by implementing the student proposing deferred-acceptance mechanism. Analyzing a centralized application process to secondary schools, Ajayi (2011) finds that imperfect information about admission chances and differing decision-making skills lead to differences in application behavior. These differences are mitigated by two recent policy reforms, which are examined as natural experiments.

More comprehensive empirical evidence exists within the related field of labor markets, i.e. matching workers to firms. The theoretical literature on centralized matching, for instance, has so far mainly been complemented by experimental and computational economics studying centrally organized entry level labor markets for e.g. new physicians in the US and the UK (e.g. Roth and Peranson, 1999; Kagel and Roth, 2000; Roth, 2002). Empirical studies evaluating the matching efficiency of decentralized labor markets predominantly employ the approach of the matching function, which describes how the stock of unemployed workers and vacancies translate into new matches/hires (see Petrongoli and Pissarides, 2001; Pissarides, 2011, for a survey). Fahr and Sunde (2009), for example, use the variation over time induced by a German labor market reform as a natural experiment to show that the reform has improved the matching efficiency of the labor market.

The German centralized college admission system is empirically analyzed by Braun et al. (2010). They show that the applied matching procedure allows for strategic behavior and moreover penalizes good secondary school graduates, although the mechanism is supposed to be designed in favor of good students. Therefore, the theoretical papers by Westkamp (2010) and Weiler (2009) suggest superior centralized matching algorithms for university admission in Germany.[3] With respect to decentralized admission in Germany, Müller (2007, 2009) describes frictions induced by the necessity for prospective students to apply at multiple universities. Thus, both the centralized and decentralized admission procedure within Germany exhibit inefficiencies.

This paper contributes to the scarce empirical literature on university admission by evaluating a change from centralized towards decentralized admission as a natural experiment. My analyses provide new empirical evidence with respect to the matching efficiency and matching quality of centralized and decentralized admission procedures. To my knowledge, no such empirical evaluation study exists as yet. Roth (2002) suggests that experimental and computational economics can complement the theory on mechanism design. Similarly, I believe that evaluation studies exploiting natural experiments also provide important complementary evidence. Moreover, the theoretical literature may identify inefficiencies in matching procedures, while empirical evaluation studies – similar to Krishna and Ünver (2008) – may also quantify how prevalent inefficiencies are in practice. My analyses are only a first attempt to evaluate different procedures of university admission. More evaluation studies exploiting reforms in college admission procedures are desirable. The extensive empirical literature on the related field of job matching may suggest appealing directions to proceed.

The results of my comparison of centralized and decentralized university admission show that the number of first-year students increased and the number of unassigned

[3]While Westkamp (2010) suggests a procedure in spirit of Gale and Shapley (1962), Weiler (2009) uses a computational optimization algorithm.

places decreased in course of the the decentralization. This suggests a superior matching efficiency within the decentralized procedure. However, considering only a sample of law schools that have kept their admission restrictions, I find no significant changes in these outcomes. Therefore, the decentralization affects the matching efficiency mainly by enabling law schools to abolish all admission restrictions. My estimates with respect to matching quality show no significant changes in the drop-out rates induced by the decentralization. Nevertheless, a comparison between the effects for all treated law schools and for the subgroup of law schools which have always applied admission restrictions suggests that abolishing admission restrictions could be associated with increasing drop-out rates.

The remainder of the paper is structured as follows. In the next section, I give a more detailed overview on the institutional background of the German higher education system as well as on the centralized and decentralized admission procedure (Section 5.2). Subsequently, Section 5.4 describes the administrative student data, Section 5.5 exhibits first descriptive evidence, Section 5.3 explains the differences-in-differences estimation strategy, and Section 5.6 presents the results. Section 5.7 concludes.

5.2 Institutional Background

Contrary to the U.S. higher education system, almost all German universities are publicly funded and administered by one of the 16 German federal states. No tuition fees existed until 2006. Usually, only a registration fee of about 100 Euro had been levied each term by the universities. Therefore, the German higher education system has been considered to be quite homogeneous with respect to university quality. However, competition between different institutions has been encouraged by recent reforms. The Bologna Process initiated in 1999 established a new Bachelor and Master degree system throughout Europe in order to create comparable tertiary degrees. This process also aims at increasing the international competitiveness of the European system of higher education.[4] Furthermore, some German federal states introduced tuition fees from 2006 onwards. As tertiary education used to be free of charge, tuition fees were – and still are – a matter of intense public discussions. Therefore, some federal states which once decided to levy fees today have already abolished them again.[5] In 2006 and 2007, the German government further ran an excellence competition awarding extra funding to the universities with the best future concept for top-level research.[6]

Along this development towards more competition in the German higher education system, the university admission process has been decentralized for some subjects. Since 1973, the central clearinghouse has allocated university places in subjects for which places were scarce. These subjects included e.g. law and medical studies, biology, psychology, and business administration. As the number of applications were decreasing over time and as students and universities recognized the central clearinghouse mainly as too bureaucratic, some subjects abolished the centralized admission process from 2002 onwards.

In the field of law studies, the student-university matching procedure was decentralized in 2002. The decision to decentralize admission to German law schools was taken very surprisingly in spring 2002. The publication of the central clearinghouse, which was used to inform the applicants of the year 2002, still indicated admission for law studies to be part of the centralized process. However, this information was revised after the decision to decentralize admission has been communicated. The decentralization induced two major changes for the admission to law schools. First, the

[4]For an evaluation of the German Bologna Process see Horstschräer and Sprietsma (2010).
[5]For analyses regarding the introduction of tuition fees in Germany see Dwenger et al. (2011) and Hübner (2009).
[6]For an evaluation of the excellence initiative see Horstschräer (2011).

student-university matching is no longer coordinated by the central clearinghouse. Prospective students after the reform, thus, apply directly at the universities and are subsequently also directly admitted by the universities. Second, universities within the decentralized admission procedure themselves decide on the admission criteria they apply and may also abolish all admission restrictions. The absence of any restrictions enabled prospective students to directly enroll into the law programs of these universities. Hence, the decentralization process can affect the outcome of the matching procedure via two channels: the abolishment of the central coordination by the clearinghouse and the annulment of admission restrictions.

Important for my estimation strategy is that admission to law schools has not been centralized within the largest German federal state of North Rhine-Westphalia. As the central clearinghouse is located within the federal state of North Rhine-Westphalia and as North Rhine-Westphalian universities were also excluded from other nationwide decentralization processes, this decision most likely was politically motivated. The central clearinghouse, therefore, has been administering admission to law schools within North Rhine-Westphalia also after the reform of 2002. As admission has been decentralized in the other federal states, prospective students could apply directly at the schools outside of North Rhine-Westphalia and simultaneously also for the centralized process within North Rhine-Westphalia.

Before comparing the different matching procedures, let me explain the German centralized matching procedure in more detail. Centralized admission in Germany consists of two separate steps. In a first step, the prospective students are selected for e.g. law studies, and in a second step, they are allocated to universities. In the first step, the central clearinghouse selected students by three different procedures, which are:

- Procedure G: Admission according to the final secondary school grade.
- Procedure W: Admission according to the time applicants have already been waiting for admission.
- Procedure U: Admission according to criteria set by the universities.[7]

These three procedures are applied sequentially. First, all university places that are supposed to be filled by procedure G are assigned, second, procedure W is applied, and last in row is procedure U. The amount of places to be filled by each procedure has been fixed in advance. In 2000 for example, 55% of the overall available university places were assigned by the secondary school grade (G), 25% by the time of waiting (W) and 20% by the universities' criteria (U). Due to political discussion and the public debate on the drawbacks of the central clearinghouse, procedure U has become more important over time. Until 1999, students have only been selected with respect to their grade and their waiting time, while, since 2005, 60% of the places are filled according to the universities' criteria. Within procedure U, many universities, however, relied on the secondary school grade as their only selection criteria (ZVS, 2000). Therefore, the influence universities gained within the centralized admission process has been limited. Furthermore, the change in the centralized procedure is only relevant for the subjects remaining nationwide centrally administered after 2002 – e.g. medical studies. Within the centralized admission process for law schools located in North Rhine-Westphalia only procedure G and W have been applied again after the reform of 2002. The selection criteria for these schools, thus, have not changed severely over time.

While prospective students in procedure U are selected and allocated in one step, students selected within procedure G and W are allocated to universities in a sepa-

[7]In fact, universities decide on the basis of the following admission criteria: (i) the final secondary school grade, (ii) interviews with the applicants, (iii) the previous working experience, or (iv) a combination of these three.

rate second step. Prospective students in these two procedures are mainly allocated according to their stated first university preference. In case more students indicated a university as their first preference than this university offered places, the secondary school grade or social criteria[8] are used for tie-breaking. If a selected student cannot be matched to his first choice, the central clearing house similarly tries to assign a place at the school of second preference. However, all applicants who listed this college as their first preference are placed at this college first. The tie-breaking rules for colleges changed several times within the observation period, but the indicated first university preference has always been most important for the allocation of prospective students in procedure G and W.

In order to relate the German admission procedure to the theoretical literature on college admission, I can describe the second step of the centralized procedure, i.e. the allocation of prospective students to universities, more formally. The allocation mechanism within procedures G and W assigns students as follows:

- *Step 1:* For each university, consider the students who indicated the according university as their *first* preference. Subsequently, assign the university places among them according to their final secondary school grade (social criteria) until all students are assigned at their *first* preference or no places remain.
- *Step k:* For each university with unassigned places, consider the students who indicated the according university as their kth preference. Subsequently, assign the university places among them according to their final secondary school grade (social criteria) until all students are assigned at their kth preference or no places remain.

[8] E.g. severe disabilities, spouse/child living close to the university, proximity to a student's hometown if registered at the parents home.

This procedure corresponds to the prominent "Boston Student Assignment Mechanism" studied within the theoretical literature on school choice. The Boston priority-matching mechanism has been shown to produce stable outcomes, i.e. a situation in which neither a student nor a college prefer one another compared to their assignment. However, the mechanism gives an incentive for strategic preference lists as prospective students may not state their true preference but choose a school as their first choice at which they have realistic chances to be admitted (Abdulkadiroglu and Sönmez, 2003).

The matching mechanism within procedure U corresponds to the college proposing deferred-acceptance mechanism. Within the matching process, the universities with q_u places admit the q_u students who rank highest with respect to the universities' preferences. Each student subsequently accepts his highest-ranked offer and rejects all others. In turn, the universities offer the places which remain unassigned after the first round to the highest-ranked applicants who have not yet accepted an offer and who have not yet received an offer by the according university. Again, students only accept the highest-ranked offer. This algorithm stops when all students are assigned or when no places remain to be allocated. The outcome of the college proposing deferred-acceptance mechanism is the stable matching most preferred by colleges and least preferred by students (Roth, 1984a). Furthermore, Roth (1985) shows that no college-optimal deferred-acceptance mechanism exists, which makes it a dominant strategy for all colleges to state their true preferences.

Within the decentralized admission process, all students apply directly at the universities. Students usually apply for multiple universities at the same time because they have imperfect information about their chances to receive an offer. At the same time, universities make more offers than their actual capacity as they must expect some students to reject their offer. The consequences of this procedure may be e.g. (too) late assignment, late enrollment, and unassigned university places (e.g. Roth and

Xing, 1994; Müller, 2007, 2009). Furthermore, if universities are overburdened with the new admission responsibilities, they may choose the wrong applicants resulting in less human-capital production or higher drop-out rates.

All in all, the theoretical evidence with respect to centralized and decentralized university admission in Germany points at possible inefficiencies in both systems. Therefore, an empirical comparison of centralized and decentralized admission procedures may provide important insights in how these inefficiencies affect the student-university matching in practice.

5.3 Estimation Strategy

For comparing the matching efficiency and the matching quality of the centralized and decentralized university admission procedure, I exploit the abolishment of the centralized admission in the field of law as a natural experiment. The applied differences-in-differences approach does not only compare the matching efficiency and quality for admission before and after the reform, but it also compares the development over time to a control group of university departments which have not experienced any change in university admission.

The decentralization of university admission in the field of law offers a setting which is very well suited for differences-in-differences estimation. As the German federal state of North Rhine-Westphalia – unlike all other federal states – has not decentralized admission to law schools in 2002, the six law schools of this state form a natural control group. This allows me to compare the development in the matching efficiency and quality over time for the treated law schools outside of North Rhine-Westphalia with the control law schools within North Rhine-Westphalia. The decision of North Rhine-Westphalia not to decentralize admission to law schools has been taken independently of the situation at North Rhine-Westphalian law schools. As the central clearinghouse is located within North Rhine-Westphalia and as also other subjects have not been decentralized in North Rhine-Westphalia, it was rather a political motive that drove this decision. Using the regional variation between federal states for identification has the advantage that I can compare schools within the same subject. Thus, differences between subjects, e.g. a different student body, do not influence my results. However, regional differences and changes in the composition of treatment and control group, i.e. prospective students now applying for law studies outside of North Rhine-Westphalia because admission has been decentralized, may affect the results of this comparison.

Therefore, I consider medical schools outside of North Rhine-Westphalia as an additional, second control group. Admission to medical schools was organized centrally over the entire observation period and thus was unaffected by the decentralization process in the field of law studies. For this second control group, it is less likely that the composition of treatment and control group changes as treatment and control group differ in subject. Furthermore, university departments of the treatment and control group in this comparison are located within the same geographical region. Thus, regional differences do not influence the estimations employing the second control group. Differing trends between both subjects over time, however, may affect this alternative differences-in-differences approach. Therefore, my estimations account for differing time trends.

Being able to apply a differences-in-differences analysis with two alternative control groups is an advantage because both approaches complement each other and therefore increase the reliability of my estimation strategy. The formal representation of the classical differences-in-differences analysis for both alternative control groups reads as follows:

$$y_{it} = \alpha_1 LAWtreated_i \times AFTER_t + \alpha_2 LAWtreated_i + \alpha_3 AFTER_t + \alpha_4 X_{it} + \epsilon_{it} \quad (5.1)$$

The outcome y_{it} for university department i in year t represents the outcome variables (i) the number of matriculated students, (ii) the number of unassigned university places and (iii) the share of drop-outs. These measures of matching efficiency and matching quality are described in more detail in Section 5.4. The classical differences-in-differences approach includes as explanatory variables a binary variable indicating the treated law schools $LAWtreated_i$ for which university admission has been decentralized, a binary variable indicating the years after the decentralization $AFTER_t$, and the interaction between these two variables $LAWtreated_i \times AFTER_t$, which coefficient represents the effect of interest. The classical approach, thus, controls for differences between treated schools and control schools and for differences over time before and after the decentralization of university admission in the field of law studies. The interaction of interest – i.e. the effect of decentralizing university admission – thus only picks up changes in matching efficiency and matching quality after the reform which are not simultaneously observed in the control group.

Furthermore, I include additional covariates X_{it} to control for the introduction of tuition fees from 2006 onwards and for the introduction of an excellence status for some universities within an excellence competition run by the German Government.[9] The covariates also include separate time trends for the treated schools and the control schools by interacting a binary variable indicating the treated schools and control schools respectively with a continuous variable for all years of observation. These interactions account for linear time trends in the treated schools and the control schools before the reform and therefore avoid a bias in the estimates merely driven

[9] For a more detailed analysis of the excellence competition see Horstschräer (2011).

by differing time trends. The descriptive evidence (Figures 5.2 - 5.4) suggests that especially subject-specific time trends may be important for the comparison with medical schools. Using a continuous year variable assumes linear time trends. This assumption is justifiable as the matching quality indicators indeed seem to develop approximately linear before the decentralization in 2002.

An alternative estimation approach exploits the panel structure of the data by accounting for university department fixed effects. With this approach, the estimation merely relies on the variation over time on the level of university departments. Everything that is constant over time for a specific law or medical school is netted out. Thus, adding the fixed effect to the estimation equation allows a more precise analysis by estimating the following equation:

$$y_{it} = \beta_1 LAWtreated_i \times AFTER_t + \beta_2 AFTER_t + \beta_3 X_{it} + \upsilon_{it} + \epsilon_{it} \tag{5.2}$$

The effect of interest is again the coefficient of the interaction $LAWtreated_i \times AFTER_t$ which estimates the effect of decentralizing university admission on the outcomes y_{it} representing matching efficiency and matching quality. In this specification, the fixed effect υ_{it} captures all school-specific and time-constant variation in matching efficiency and quality. Therefore, the time-constant indicator variable $LAWtreated_i$ is not identifiable – in other words not necessary – and is thus dropped. All other covariates are the same as in Equation 5.1. The standard errors are clustered by university departments.

The decentralization of university admission for law studies in 2002 is a suitable natural experiment in university admission for several reasons. First, it offers two appropriate control groups to identify the effect of decentralizing university admission. Second, it allows me to disentangle the change in university admission from the

European Bologna Process introducing a new (Bachelor and Master) degree system throughout Europe. Until this day, the degree system in law and medical studies remains unaffected by the Bologna Process. As a certain quality standard of law and medical graduates is of public interest, the final degree in both subjects has always been a centralized national exam. Third, the decentralization in law studies was already implemented in 2001, which offers the opportunity to observe five post-treatment years that are not affected by the introduction of tuition fees in some federal states. Fourth, the same timing argument applies for the excellence competition carried out by the German government in 2006 and 2007. Hence, the natural experiment in university admission for law studies allows me to identify the isolated effect of a change from a centralized towards a decentralized admission procedure.

5.4 Data

For the evaluation of the change from a centralized towards a decentralized university admission, I use administrative student data comprising individual information on all matriculated students in Germany over the years 1995 to 2008. The data set is provided by the statistical offices of Germany and relies on the registration data reported by each German university.[10] The advantage of the administrative student data is that I can observe *all* students in Germany over a long period of time. The data set contains detailed information on the course of studies and a limited number of student background variables.

The outcome measures I use to evaluate the decentralization of university admission aim at assessing the matching efficiency and the matching quality of the admission procedure. Matching efficiency in this context means the quantitative outcome of the

[10] Statistical Office Germany, Higher Education Statistics.

admission process, e.g. the number of students that are matched to a university. This aspect is important as it may reveal that the admission procedure yields an inefficient use of resources, which might be the case if not all supplied university places can be filled. The matching quality additionally evaluates whether students are assigned at universities that fit them with respect to e.g. their preferences or ability. The outcome measures I use to proxy matching efficiency and matching quality are:

1. The number of first-year students

2. The number of unassigned university places

3. The drop-out rate

The number of first-year students assesses the matching efficiency of the student-university matching, i.e. the number of recently matriculated students. This outcome variable has been chosen in spirit of the matching function applied by the empirical literature on job-matching, in which new hires represent the job-matching outcome. For transferring the job matching function concept to student-university matching one-to-one, I would need to explain the number of first-year students by the number of applicants and the number of supplied university places. Unfortunately, no data on the number of applicants is available for the law schools which decentralized admission. Therefore, I use the number of first-year students as a first crude proxy for the matching efficiency and take the number of supplied university places into account for my second outcome variable.

The second outcome measure of the matching efficiency is the number of unassigned university places, i.e. the difference between the number of university places a university supplies and the number of first-year students.[11] This second indicator allows

[11]The numbers of supplied university places for the universities within the centralized admission procedure have been provided by the central clearinghouse. The according data for the law schools

a more detailed analysis with respect to the matching efficiency as it takes the supply side into account. The effect of the decentralization on this outcome is especially interesting as a high number of unassigned places has often been mentioned as a disadvantage of the less regulated decentralized admission procedure. It is also important to mention that the differences between the amount of supplied university places and the number of matriculated students can turn negative if the number of matriculated students exceeds the a priori fixed amount of university places to be supplied. This situation occurs for example if more students than expected accept a university's offer.[12] Also, for this second outcome it would be desirable to account for the number of applicants in order to focus solely on the matching efficiency. As this data is unfortunately not available, the second measure of matching efficiency – the number of unassigned university places – can also be influenced by changing numbers of applicants. The measures of matching efficiency therefore may also comprise the attractiveness to apply for studies under the respective admission procedure.

The third outcome measure I consider is the drop-out rate within the first year of studies. It proxies the matching quality. As students who are allocated to a university that does not fit them – with respect to their preferences or ability – will face a higher risk of dropping out, the drop-out rate measures the consequences of the initial matching quality. The drop-out rate of university i for the first-year students of year t is calculated by dividing the number of second-year students at university i in year $t+1$ by the number of first-year students at university i in year t. I restrict my analysis to the drop-outs after one year of studies as most drop-outs occur within the first year. Furthermore, by restricting my analysis to a one-year time lag, I lose only one year of observation (2008) for the drop-out analysis. Due to a missing

with decentralized admission has been inquired directly at all 16 federal state ministries of education and research. For the federal state of Bavaria, I had to contact each university directly as the state ministry could not provide the data.

[12]In fact, the number of matriculated students is regularly above the fixed number of university places within the centralized admission procedure (see Figure 5.3 in Section 5.5).

panel identifier on an individual level, I am not able to construct the individual drop-out rate. The drop-out rate, as I define it, thus also captures the likelihood that a student completely cancels his studies as well as the likelihood that he changes subject or university within his first year of studies. Therefore, the drop-out rate is a measure of the universities' ability to retain its students. This approximation seems to be reasonable because changes between universities are not very common within the first year of studies.

For the differences-in-differences analysis, I apply two different samples. In order to compare law schools in (control) and outside of (treated) the federal state of North Rhine-Westphalia, I keep all German law schools (in and outside of North Rhine-Westphalia) in the first sample. All university departments of other subjects are dropped. The second sample consists of all law (treated) and medical (control) schools outside of North Rhine-Westphalia. Thus, I delete all departments of other subjects and all observations from within North Rhine-Westphalia. In both samples, I do not consider students at two private universities[13] as they have never been part of the centralized admission process. Furthermore, I also restrict my analysis to the semesters starting in fall. Although university admission in general is possible twice a year – for the semester starting in spring and for the semester starting in fall – many universities only admit students in fall.

All three outcomes are measured on the university department level. Therefore, I aggregate the data by university departments.[14] By aggregation, I obtain a panel data set of law and medical schools. Table 5.1 lists the number of law and medical schools in the sample for each year of the observation period. The table depicts the

[13] The University of Witten/Herdecke is the only private institution offering Medical Studies and the Bucerius Law School the only private school in the field of Law.

[14] An analysis on the individual student level could also provide interesting insights e.g. with respect to the drop-out risk and the amount of human-capital acquisition. However, the current data protection law in Germany does not allow to follow individual students over time. Therefore, a panel identifier on the individual student level is not available for the data.

Table 5.1: Number of Law and Medical Schools by Year (1995-2008)

	1995	1996	1997	1998	1999	2000	2001
Law Schools "treated" *(not in North Rhine-Westphalia)*	33	34	33	34	34	34	34
Law Schools "control 1" *(in North Rhine-Westphalia)*	6	6	6	6	6	6	6
Medical Schools "control 2" *(not in North Rhine-Westphalia)*	24	26	25	26	26	26	26
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Law Schools "treated" *(not in North Rhine-Westphalia)*	34	34	33	33	33	33	32
Law Schools "control 1" *(in North Rhine-Westphalia)*	6	6	6	6	6	6	6
Medical Schools "control 2" *(not in North Rhine-Westphalia)*	26	26	26	26	26	26	26

Data Source: Administrative Student Data (1995-2008), own calculations.

treated law schools and the two control groups separately.[15] In general, my data contain all public law and medical programs existing in Germany. Only in two years few observations are missing due to non-reported data of two federal states.

Until 2003, 34 law schools existed outside of North Rhine-Westphalia. Data for one law school is missing in 1995 (University of Kiel) and for another one in 1997 (University of Hamburg). These two schools are missing because data on the federal state of Schleswig-Holstein (1995) and Hamburg (1997) are not available. These missing observations are most likely missing at random as the federal states have not reported any data merely due to administrative problems. In 2004, the University of Dresden and, in 2008, the University of Rostock closed their law programs. Consequently, the number of treated law schools drops to 33 between 2004 and 2007 and to 32 in 2008.

[15] For a more detailed list of all included law and medical schools see Table A.5.2 in the Appendix.

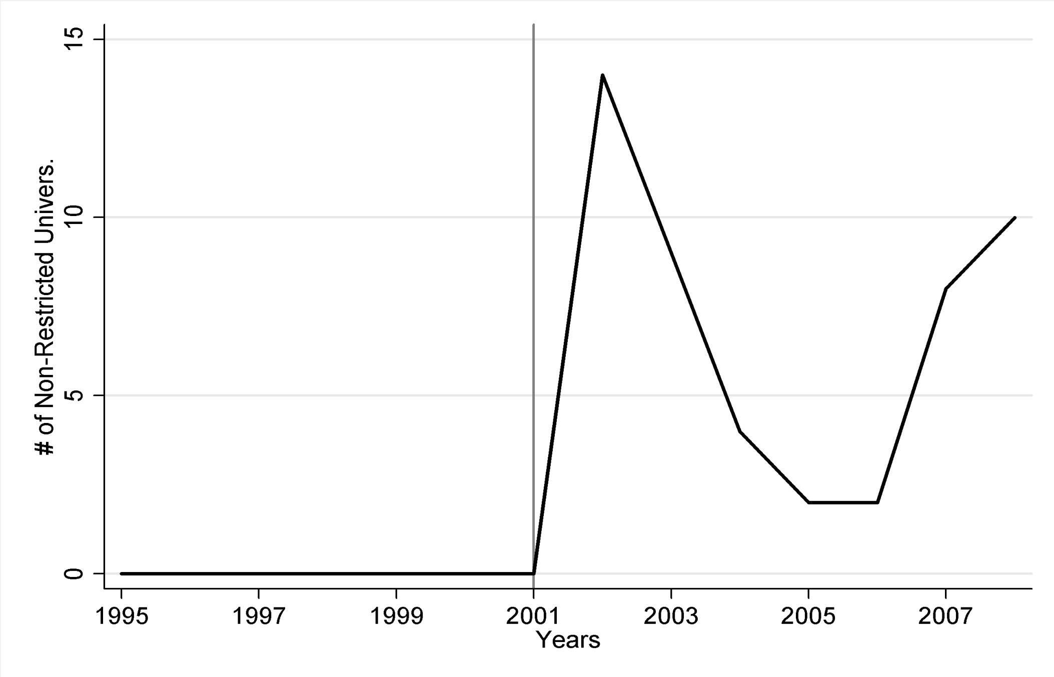
Within North Rhine-Westphalia, six law schools exist over the entire observation period. Thus, although North Rhine-Westphalia is the largest German federal state, the first control group is rather small. Therefore, I also consider all medical schools outside of North Rhine-Westphalia as a second control group, which consists of 26 medical schools over the entire observation period. Data are only missing for two medical schools (University of Kiel and University of Lübeck) in 1995 and for one (University of Hamburg) in 1997. Again, the missing data is due to the unavailable data of the two federal states Schleswig-Holstein and Hamburg.[16] The first sample that I use for the comparison between law schools in and outside of North Rhine-Westphalia, thus, consists of a total of 552 school-year observations. The second sample comprises the treated law schools and the control medical schools outside of North Rhine-Westphalia, which together amount to 829 school-year observations.

The panel of law and medical schools is not balanced over all years as data for two federal states are missing for one year each and as two universities closed their law programs. However, the number of law and medical schools in Germany overall has been very stable within the entire observation period. This ensures that the possibilities to study one of these two subjects (supply side) have not changed severely over time.

Despite the number of law and medical schools being very stable over time, admission restrictions in the field of law changed in the course of decentralizing admission. Figure 5.1 shows that, until 2002, all law schools had to fix the number of university

[16]Note also that the two medical schools in Munich (Technical University and Ludwig-Maximilian University) merged their programs already in 2000 and that Berlin merged its two programs (Free University and Humboldt University) in 2003. Therefore, I aggregate the number of students of both medical programs in Munich and in Berlin in all years. Furthermore, the University of Heidelberg offers two medical science programs, one combined with the University of Mannheim. Although students apply separately for both programs, matriculated students are not reported disaggregated in the administrative student data. Therefore, I consider both programs as one.

Figure 5.1: Number of Universities with no Admission Restrictions (1995-2008)



Data Source: Administrative Student Data (1995-2008), own calculations.

places they were able to supply.[17] After the decentralization, 14 law schools allowed prospective students to directly enroll into their program without any admission restrictions. This number dropped again to only two law schools with unrestricted admission in 2005 and 2006 and subsequently increased to nine and ten schools in 2007 and 2008. These frequent changes in admission restrictions directly after the decentralization, presumably, indicate that some law schools were experimenting to find a suitable admission procedure.

In order to distinguish the effect of abolishing all admission restrictions from abolishing the central coordination by the central clearinghouse, I estimate the decentraliza-

[17]However, for some unpopular universities these numbers in fact did not restrict admission because the universities - especially in the years prior to the decentralization - could not fill all supplied places (see Figure 5.3).

tion effect also on a sample only consisting of universities that never (not in a single year) abolished their admission restrictions. This constraint in general reduces the number of treated law schools in the sample from 34 to 16 schools for which admission has always been restricted. As admission to the control law and medical schools has always been restricted within the centralized admission procedure, no observations of the control groups are dropped. As a consequence, the number of observations in the first sample, using the law schools in North Rhine-Westphalia as controls, drops from 552 observations to 301. The second sample, including the medical schools outside of North Rhine-Westphalia as controls, is reduced from 829 to 578 observations.

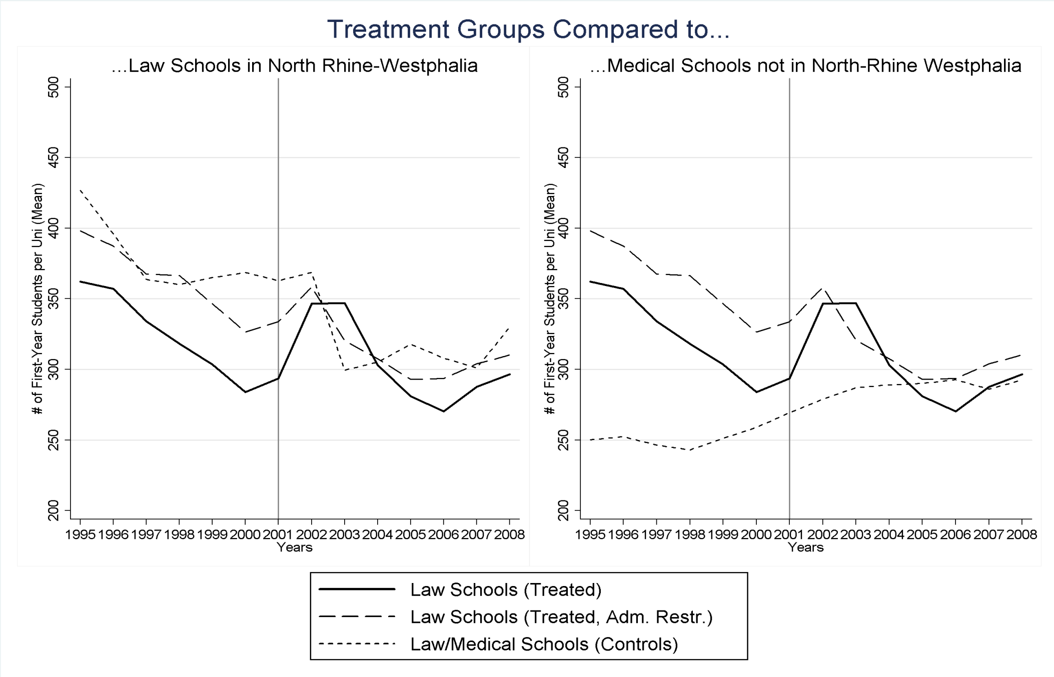
5.5 Descriptive Evidence

By depicting the development of the three different matching outcomes over time, I provide first descriptive evidence on whether the matching efficiency and the matching quality have changed in the course of decentralizing university admission. Furthermore, the descriptive analyses investigate whether the differences-in-differences assumption of common trends between treatment and control group applies. Therefore, Figures 5.2 - 5.4 depict the development over time for the number of first-year students, the number of unassigned university places, and the drop-out rate.[18]

Figure 5.2 compares the number of first-year students at the treated law schools outside of North Rhine-Westphalia with the law schools in North Rhine-Westphalia (first control group) and with the medical schools outside of North Rhine-Westphalia (second control group). Immediately after the decentralization of university admission, I observe a temporary increase in newly matriculated students from on average 300 students per university in 2001 to on average 350 students in 2002 and 2003

[18] For a mean comparison of all three outcomes see also Table A.5.1 in the Appendix.

Figure 5.2: Number of First-year Students over Time (1995-2008)



Data Source: Administrative Student Data (1995-2008), own calculations.

for the treated law schools. This sudden increase after the decentralization is even more remarkable as the number of first-year students has been constantly decreasing prior to the decentralization. After 2003, the numbers of first-year students, however, decreased again and reached a level of about nearly the same level as before the decentralization in 2001. If I restrict the sample to the treated law schools that never dropped their admission restrictions, I only observe a slight increase in first-year students for one year after the decentralization of admission. Thus, the temporary increase in first-year students at all treated law schools seems to be mainly driven by the schools which temporarily abolish all admission restrictions, i.e. which enable students to directly enroll into their law programs.

Comparing the two groups of treated law schools to the control law schools in North Rhine-Westphalia (left panel in Figure 5.2) does not indicate a change in the average number of first-year students at the control law schools in the year directly after the decentralization. After 2002 however, the number of newly matriculated students drops from above 350 students on average to about 300 students on average. This suggests that the composition of the control law schools might indeed be affected by the decentralization with a little time lag. The differences-in-differences assumption of common trends, however, is supported as the development of the treatment and control law schools over time is very similar prior to the reform in university admission. The comparison with the medical schools outside of North Rhine-Westphalia (right panel in Figure 5.2) shows that the number of first-year students within the second control group does not seem to be influenced by the decentralization process. The number of matriculated students at medical schools is constantly increasing to a moderate extent over the entire observation period. The development of the treatment and the second control group over time differ prior to the reform. Accounting for differing time trends, therefore, is more important for the comparison with the control medical schools.

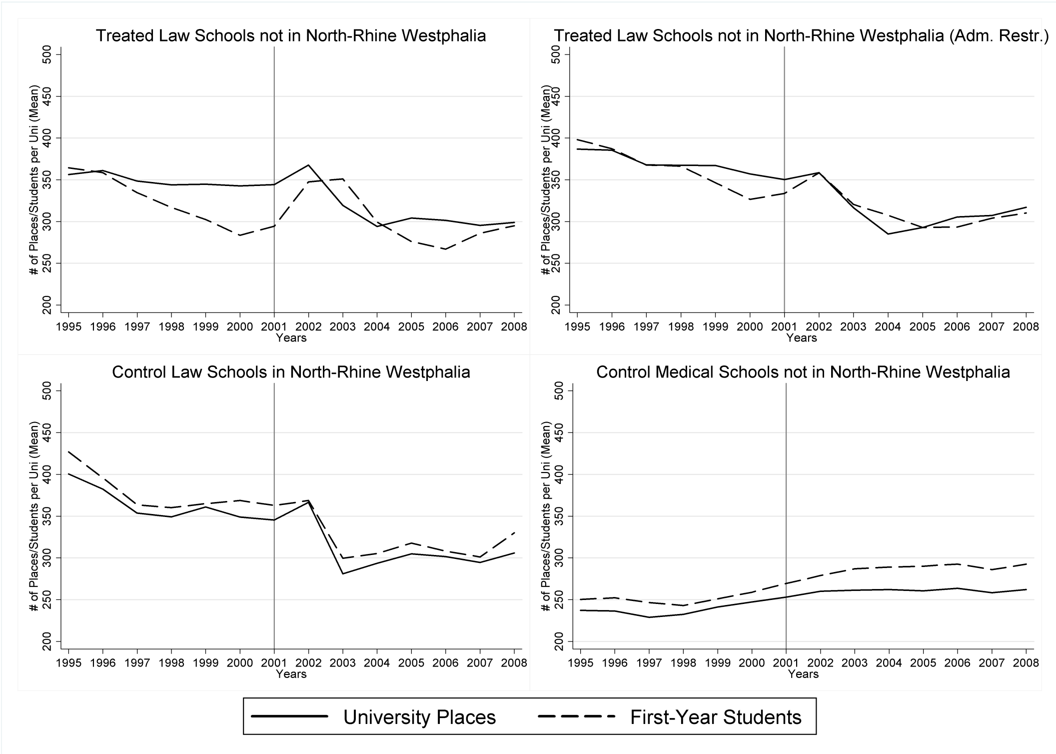
As the development over time of the number of supplied university places is similar to the development of the number of first-year students (see Figure 5.3), a change in the number of first-year students after the decentralization could also be merely induced by adjustments in the supply of places. Therefore, Figure 5.3 depicts the difference between the number of university places and the number of first-year students per university, i.e. the number of unassigned university places, which is an important second outcome with respect to the matching efficiency.

For both treatment groups (two panels at the top of Figure 5.3), the number of first-year students and the number of supplied university places diverge prior to the decentralization. Neither the number of supplied places nor the matching mechanism changed within this period. Therefore, this development is most likely driven by decreasing numbers of applications. This interpretation is even more likely as one argument for the decentralization of admission has been that the supply of places is not scarce anymore. The gap between the actually matriculated students and the supplied places is larger in the sample containing all treated law schools than in the restricted sample. Thus, I can infer that mainly the less demanded universities decided to drop all admission restrictions. After the decentralization, the average number of first-year students – as already shown in Figure 5.2 – increases instantaneously. In addition, the number of supplied places also increases in 2002, however, only to a very moderate extent. This development of the number of first-year students and supplied university places results in a decrease of unassigned university places. Within the sample of treated law schools applying admission restrictions in all years, the decrease in the number of unassigned places (as also the increase in matriculated students – see Figure 5.2) has been smaller than within the full sample of treated law schools. In the following years, the universities sometimes admitted more students than they had offered places, and sometimes places remained unassigned. Despite smaller gaps between the number of university places and the number of first-year students after the decentralization, it seems as if universities that were responsible for admission themselves were not able to allocate places very precisely.

Centralized admission to the control law and medical schools seems to yield a precise matching with a low level of unassigned places (see two panels at the bottom of Figure 5.3). In fact, the average number of first-year students is always above the a priori fixed number of supplied university places within both control groups. It seems as if the centralized procedure admits rather too many than too few prospective students.[19] The centralized matching procedure, nevertheless, seems to be more precise compared to the decentralized admission as the difference between the supplied

[19] As universities within the centralized admission process still directly admit foreign students, this could – at least to some degree – also induce the too high numbers of first-year students.

Figure 5.3: Number of University Places and First-year Students over Time (1995-2008)

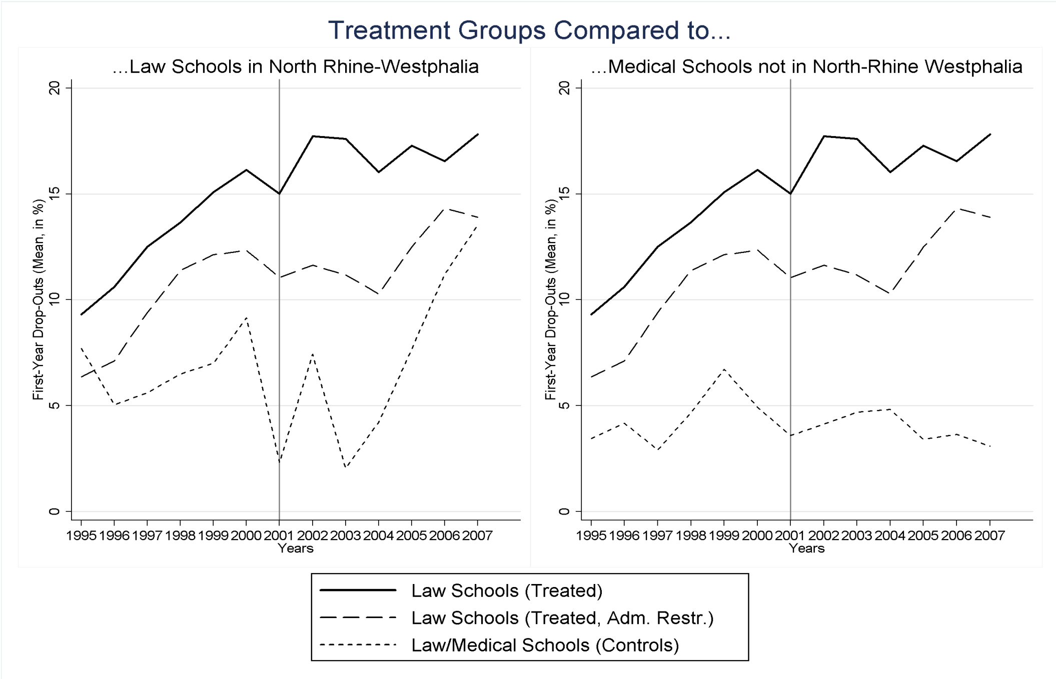


Data Source: Administrative Student Data (1995-2008), own calculations.

places and the newly matriculated students is basically constant over time. While the control medical schools do not seem to adjust their number of supplied places in course of the reform, the control law schools seem to adjust their supply similar to the treated law schools. This indicates again that the composition of the control group of law schools may not be independent of the reform process.

Descriptive evidence with respect to the drop-out rates exhibits no explicit influence of the decentralization process (Figure 5.4). Neither the treatment groups nor the control groups show major changes in drop-outs from 2002 onwards. Furthermore, the development over time is fairly similar for both treatment groups, which suggests

Figure 5.4: Mean Drop-out Rates over Time (1995-2008)



Data Source: Administrative Student Data (1995-2008), own calculations.

that abolishing all admission restrictions does not affect drop-out rates. Drop-outs at all treated law schools increase between 1995 and 2008 from about 10% on average to nearly 20% on average. The drop-out rate at the control law schools in North Rhine-Westphalia is lower compared to the other German law schools.[20] Average drop-out rates at the control medical schools are also low (about 5%) and hardly change over the entire observation period.

In order to compare the treated schools and control schools more precisely, I use differences-in-differences estimations. This multivariate approach also allows me to account for other factors that may influence my outcome variables.

[20]The average drop-out rate at the control law schools is fairly volatile. This is due to measuring the drop-out rate on the department rather than on the individual level and due to the small sample size of only six schools.

5.6 Results

The results of the differences-in-differences estimations are presented separately for the three outcomes (i) the number of first-year students, (ii) the number of unassigned university places, and (iii) the drop-out rate. I estimate different Ordinary Least Squares (OLS) models using both control groups – the law schools located in North Rhine-Westphalia and the medical schools outside of North Rhine-Westphalia. The presented models are a standard OLS regression (OLS), an OLS school fixed effect model (OLS FE I) and an OLS school fixed effect estimation using a sample that is restricted to the treated law schools that have never abolished their admission restrictions (OLS FE II).

5.6.1 Number of First-Year Students

Table 5.2 presents the results with respect to the number of first-year students when using the law schools of North Rhine-Westphalia as controls. The classical differences-in-differences estimates in the first column indicate a weakly significant increase in the number of first-year students after the decentralization of admission. After the reform, on average 42 more students matriculated at the treated law schools. The control variables account for significantly less matriculated students at the law schools outside of North Rhine-Westphalia and significantly less students at all law schools from 2002 onwards.

Controlling for additional covariates and treatment- and control-specific time trends (column 3) increases the treatment effect to about 89 students per treated law school. The estimate of interest remains weakly significant. The significance of the other covariates, however, mainly disappears when I control for differing time trends. The

Table 5.2: The Effect of Decentralized Admission on the Number of First-Year Students (Controls: Law Schools in North Rhine-Westphalia)

	OLS	OLS	OLS	OLS FE I	OLS FE II
Law Treated × After	42.39*	31.16	88.79*	85.67**	35.48
	(25.25)	(25.43)	(49.32)	(22.78)	(25.48)
Law Treated	-56.05***	-56.05***	-27.23	–	–
	(17.84)	(17.70)	(30.25)		
After	-58.95**	-45.31*	-13.24	-13.74	-8.66
	(23.25)	(24.09)	(45.72)	(17.03)	(17.27)
Covariates					
Tuition Fees		-31.84**	6.60	2.68	18.48
		(16.17)	(17.66)	(10.28)	(11.33)
Excellence Labels		134.66***	227.02***	47.42	52.22*
		(45.03)	(44.20)	(29.13)	(28.64)
Time Trends					
Law Treated × Year			-13.93***	-13.00***	-11.87***
			(2.58)	(2.19)	(2.80)
Law Control × Year			-6.79	-6.62	-8.32*
			(5.94)	(4.00)	(4.15)
N	552	552	552	552	301
R^2	0.0298	0.0483	0.0972	0.1571	0.3101

Data Source: Administrative Student Data (1995-2008), own calculations; clustered standard errors in parentheses; */**/*** indicate significance at the 10/5/1 percent level.

treated law schools show a significantly negative time trend prior to the reform, while the slightly negative time trend for the control law schools is not significant. Estimating the same specification in an OLS school fixed effect setting (OLS FE I) does not change the estimates remarkably. I find a significant increase in matriculation by about 86 students when accounting for the negative time trend at the treated law schools.

The decentralization of university admission, however, has no significant effect on the number of first-year students if I restrict the sample to the law schools that have always – also after the reform – applied admission restrictions. This suggests that the

Table 5.3: The Effect of Decentralized Admission on the Number of First-Year Students (Controls: Medical Schools not in North Rhine-Westphalia)

	OLS	OLS	OLS	OLS FE I	OLS FE II
Law Treated × After	-51.45***	-49.70***	46.18	49.70**	2.65
	(16.62)	(16.26)	(32.16)	(19.05)	(21.72)
Law Treated	68.38***	68.38***	123.91***	–	–
	(11.76)	(11.50)	(19.73)		
After	34.89***	30.93**	32.72	24.67*	27.12**
	(12.49)	(12.50)	(24.41)	(12.61)	(12.82)
Covariates					
Tuition Fees		-18.92	6.60	8.10	20.13
		(15.49)	(16.44)	(12.12)	(15.28)
Excellence Labels		221.02***	227.02***	82.34	83.42
		(35.57)	(35.10)	(59.30)	(59.88)
Time Trends					
Law Treated × Year			-14.76***	-13.61***	-12.60***
			(2.79)	(2.19)	(2.92)
Medicine × Year			-.93	.93	.27
			(3.14)	(2.35)	(2.43)
N	829	829	829	829	578
R^2	0.0422	0.0855	0.1157	0.1232	0.1647

Data Source: Administrative Student Data (1995-2008), own calculations; clustered standard errors in parentheses; */**/*** indicate significance at the 10/5/1 percent level.

estimated increase in matriculated students is mainly driven by law schools enabling students to directly enroll into their program. It is likely that prospective students are attracted to studying law at the schools which dropped admission restrictions by the possibility to directly enroll into their law program. This is especially likely for applicants who prefer to stay at their local university as they are guaranteed a place by enrolling directly.

Estimating the differences-in-differences models with the medical schools outside of North Rhine-Westphalia as controls yields similar results (see Table 5.3). The OLS fixed effect model (OLS FE I) suggests a significant increase by about 50 students after admission has been decentralized. Again, this effect does not persist if I restrict the sample to the law schools for which admission has always been restricted. The effect of interest is negative in the classical differences-in-differences approach but changes in sign when I add the subject-specific time trends. As I observe different time trends for law and medical schools in the number of first-year students (see Figure 5.2), accounting for different time trends is particularly important for the estimations using this second control group.

5.6.2 Number of Unassigned University Places

Another outcome measuring the matching efficiency is the number of unassigned university places. The advantage of this outcome is that it accounts for changes in the number of supplied university places and thus can show whether the increase in newly matriculated students merely reflects the increasing supply of university places. The estimation results for this outcome are presented in Table 5.4. Using the final specification of Tables 5.2 and 5.3, I find that the number of unassigned places at treated law schools decreased after the change towards a decentralized admission. Employing the law schools within North Rhine-Westphalia (the medical schools not in North Rhine-Westphalia) as a control group, yields an estimate of on average 63 (48) less unassigned places per university in the OLS model. However, I once again only observe this decrease in the number of unassigned places in the sample including all treated law schools. For the law schools that restricted admission also after the decentralization, the estimations do not reveal a significant influence of the change in admission procedures.

Table 5.4: The Effect of Decentralized Admission on the Number of Unassigned University Places

	OLS	OLS FE I	OLS FE II
Control Group: Law Schools in North Rhine-Westphalia			
Law Treated × After	-63.00**	-52.09***	-35.65
	(25.66)	(17.40)	(24.20)
Law Treated	9.01	–	–
	(15.69)		
After	1.57	2.11***	1.83
	(23.41)	(7.75)	(7.74)
N	496	496	301
R^2	0.1343	0.1194	0.0629
Control Group: Medical Schools not in North Rhine-Westphalia			
Law Treated × After	-47.98***	-37.95**	-23.11
	(14.28)	(16.46)	(23.33)
Law Treated	6.90	–	–
	(8.62)		
After	-14.88	-13.05***	-13.02***
	(10.37)	(4.71)	(4.66)
N	773	773	578
R^2	0.2319	0.1245	0.0947

Data Source: Administrative Student Data (1995-2008), own calculations; clustered standard errors in parentheses; */**/*** indicate significance at the 10/5/1 percent level; additional covariates: tuition fees, excellence labels, treatment- and control-specific time trends.

Hence, taking the number of supplied university places into account shows that the increase in first-year students exceeds the increase in supplied university places. The resulting reduction of unassigned places is, as the increase in first-year students, mainly driven by abolishing admission restrictions. Therefore, my results with respect to the first and second matching outcome suggest that the matching efficiency improved after the decentralization by enabling less demanded universities to directly enroll prospective students without any admission selection. Note, however, that the underlying increase in first-year students could also be driven by an increase in applicants. Due to a lack of data, I cannot control for changes in the number of applicants. Thus, my measures of the matching efficiency also encompass changes in the attractiveness to apply before and after the decentralization.

5.6.3 Drop-Out Rate

Estimating the influence of the decentralization process on the drop-out rate is especially interesting as the drop-out rate is an outcome with practical relevance, which is difficult to assess in a theoretical framework. As some law schools had to drop all admission restrictions in order to attract more students, the composition of the student body could be affected. For example, students could be less suited for the subject of law studies or for the respective university because students' ability to pursue studies is not assessed a priori by any admission criteria. Consequently, an increase in drop-out rates could be expected. Whether the empirical data supports this hypothesis is explored by my estimations with respect to the drop-out rate. The estimation results are displayed in Table 5.5.

All specifications using both control groups show no significant effect of decentralizing admission. However, the treatment effect is positive in the estimations on the full sample of treated law schools (OLS, OLS FE I) and negative in the estimations on the restricted sample of law schools that keep their admission restrictions (OLS FE II). Despite all treatment effects being insignificant, this seems to support the above stated hypothesis that lower admission restrictions could attract students with a higher drop-out probability.

Table 5.5: The Effect of Decentralized Admission on Drop-Out Rates

	OLS	OLS FE I	OLS FE II
Control Group: Law Schools in North Rhine-Westphalia			
Law Treated × After	1.73	1.63	-1.39
	(4.30)	(4.59)	(4.64)
Law Treated	6.63**	–	–
	(2.74)		
After	-2.14	-1.97	-1.37
	(3.98)	(4.32)	(4.24)
N	513	513	279
R^2	0.1526	0.1244	0.0959
Control Group: Medical Schools not in North Rhine-Westphalia			
Law Treated × After	.21	.10	-2.58
	(2.95)	(3.40)	(3.42)
Law Treated	6.27***	–	–
	(1.89)		
After	-.65	-.30	-.05
	(2.23)	(3.39)	(3.47)
N	769	769	535
R^2	0.2391	0.0578	0.0328

Data Source: Administrative Student Data (1995-2008), own calculations; clustered standard errors in parentheses; */**/*** indicate significance at the 10/5/1 percent level; additional covariates: tuition fees, excellence labels, treatment- and control-specific time trends.

5.7 Conclusion

This paper set out to examine a natural experiment in university admission. Using a differences-in-differences approach, I estimate the effect of decentralizing admission to German law schools (outside the federal state of North Rhine-Westphalia) on the efficiency and the quality of the resulting student-university matching. My estimation strategy employs two different control groups for which admission has been centrally administered over the entire observation period. The first group are the law schools within North Rhine-Westphalia, and the second are the medical schools outside of North Rhine-Westphalia. Moreover, the administrative student data on all students within Germany allow me to measure the effect with respect to three different outcomes: (i) the number of first-year students, (ii) the number of unassigned university places, (iii) the drop-out rate. My quantitative evaluation complements the prominent theoretical literature on college admission and its matching efficiency. The advantage of evaluation studies, in this context, is that they can also quantify how prevalent (theoretically identified) inefficiencies are in practice.

My results show that the number of first-year students on average increased and that the number of unassigned places on average decreased at the law schools which decentralized admission. This increase in the matching efficiency is mainly driven by law schools abolishing all admission restrictions, which enabled students to enroll into a law program without any application process. In fact, my estimations show no significant effect of the decentralization for the highly demanded schools which always restricted admission. However, the decentralization has positive effects with respect to the matching efficiency for the less demanded schools because they can adjust or completely abolish their admission restrictions. As the matching efficiency increases by lowering admission restrictions, the decentralization of admission could also be associated with a decreasing matching quality assessed by the drop-out rate.

My results show no significant effects in this dimension but hint at higher drop-out rates for universities softening admission restrictions.

The improved matching efficiency after the decentralization is based on an increase in matriculated students. This increase may also be driven by changes in the number of applicants before and after the decentralization process. As no data on the number of applicants is available for the law schools which decentralized admission, I cannot control for changes in the number of applicants. Therefore, my outcomes with respect to the matching efficiency might also capture the difference in the attractiveness to apply before and after the reform. In order to evaluate merely the matching mechanism, it would be necessary to take the number of applicants into account. If this data were available, an estimation strategy corresponding to the empirical job matching literature could be a possible path to proceed. The matching function for student-university matching would need to describe how the stock of applicants and supplied university places translate into the matching outcome of newly matriculated students.

In this regard, I believe that my study is only a first attempt to evaluate a reform in university admission with respect to its matching outcomes in practice. Further research exploiting other natural experiments in university admission is highly desirable. For example, a comparison of a theoretically more efficient centralized system with a decentralized system is interesting empirical work for future research. Moreover, also changes within centralized admission procedures are important to evaluate in order to improve our knowledge on optimal matching procedures. Assessing the differences in real-life outcomes between the centralized student- and college-optimal matching algorithm could be very promising as both procedures are efficient from a theoretical perspective. Such an emerging empirical literature exploiting natural experiments in the admission process could take on an important role in assessing how different admission procedures affect the student-university matching in practice and, consequently, in designing better matching procedures.

Considering the theoretical knowledge on the optimality of different matching algorithms, it is surprising how diverse admission procedures are organized all over the world. At present, several countries are discussing to reform their centralized admission procedure. German politicians and practitioners, for instance, have been discussing a new university admission procedure for several years now. Furthermore, the central authority 'UCAS' administering admissions in the UK initiated the "Admissions Process Review" that is supposed to "map future models of admissions that could deliver improved efficiencies" (UCAS, 2011). Within this transformation process, evaluating already existing admission procedures could be an important factor.

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Appendix

Table A.5.1: Mean Statistics of First-year Students, Unassigned University Places and Drop-out Rates

	Before Decentralization		After Decentralization	
	Mean	Std. Dev.	Mean	Std. Dev.
	Treated Law Schools not in North Rhine-Westphalia			
First-year Students	321.5	105.0	305.0	113.1
Unassigned Places	26.9	62.0	22.24	54.7
Drop-out Rate	13.2	7.9	17.2	8.9
	Treated Law Schools not in North Rhine-Westphalia (Adm. Restr.)			
First-year Students	360.5	117.2	313.0	115.6
Unassigned Places	8.3	50.6	4.8	38.8
Drop-out Rate	10.0	8.3	12.3	8.0
	Control Law Schools in North Rhine-Westphalia			
First-year Students	377.6	107.3	318.6	69.4
Unassigned Places	-14.5	23.0	-11.8	28.2
Drop-out Rate	6.2	8.9	7.7	12.4
	Control Medicine Schools not in North Rhine-Westphalia			
First-year Students	253.1	104.7	288.0	150.6
Unassigned Places	-13.6	26.9	-26.9	48.2
Drop-out Rate	4.4	15.1	4.0	7.4

Data Source: Administrative Student Data (1995-2008), own calculations.

Table A.5.2: Universities Offering Law and/or Medical Studies in or Outside of North Rhine-Westphalia

University of...	Law	Medicine	North Rh.-Westph.	University of...	Law	Medicine	North Rh.-Westph.
Aachen	no	yes	yes	Heidelberg	yes	yes	no
Augsburg	yes	no	no	Jena	yes	yes	no
Bayreuth	yes	no	no	Kiel	yes	yes	no
Berlin (Charité)	no	yes	no	Cologne	yes	yes	yes
Berlin (Humboldt)	yes	no	no	Constance	yes	no	no
Berlin (Free U.)	yes	no	no	Leipzig	yes	yes	no
Bielefeld	yes	no	yes	Lübeck	no	yes	no
Bochum	yes	yes	yes	Magdeburg	no	yes	no
Bonn	yes	yes	yes	Mainz	yes	yes	no
Bremen	yes	no	no	Mannheim	yes	no	no
Dresden	yes	yes	no	Marburg	yes	yes	no
Duisburg-Essen	no	yes	yes	Munich	yes	yes	no
Düsseldorf	yes	yes	yes	Münster	yes	yes	yes
Erlangen-Nuremberg	yes	yes	no	Osnabrück	yes	no	no
Frankfurt(Main)	yes	yes	no	Passau	yes	no	no
Frankfurt(Oder)	yes	no	no	Potsdam	yes	no	no
Freiburg	yes	yes	no	Regensburg	yes	yes	no
Giessen	yes	yes	no	Rostock	yes	yes	no
Göttingen	yes	yes	no	Saarbrücken	yes	yes	no
Greifswald	yes	yes	no	Trier	yes	no	no
Halle	yes	yes	no	Tübingen	yes	yes	no
Hamburg	yes	yes	no	Ulm	no	yes	no
Hannover	yes	yes	no	Würzburg	yes	yes	no

Data Source: Administrative Student Data (1995-2008).

6 Conclusion

The history of the German education system is characterized by several reform processes and broad debates about the design of educational institutions. In 1964 already, Georg Picht proclaimed the German "catastrophe of education" ("Bildungskatastrophe"). Several attempts to improve students' competencies by reorganizing the institutional setting have been undertaken since. However, it is not known which reforms have improved student outcomes and which changes have had no or even a negative effect.

Today, new empirical research methods and a better data availability within the field of education research allow to evaluate the latest reforms of the education system. This thesis, therefore, examined some specific aspects of the most recent debates and changes within the German education system. My studies focus on both fringes of the institutional system: early and higher education. Chapter 2 sheds light on the effect of school entrance screenings and their importance for developmental heterogeneity within a class. In Chapter 3 the Bachelor introduction as a part of the Bologna Process in higher education is evaluated, Chapter 4 asks whether prospective students respond to university rankings and the university's excellence status, and Chapter 5 discusses the matching efficiency and matching quality of centralized and decentralized university admission procedures.

The analyses with respect to school entrance show that strict cutoff rules determine school entry merely by age, while school entrance screenings consider also a child's developmental status. By not recommending younger and developmentally disordered children, they have the chance to catch up during a one-year delay of school. Therefore, the school entrance screenings set a minimum development requirement for school entry and harmonize the school entering cohort with respect to age and development. Hence, flexible school entry rules – particularly standardized entrance examinations – could mitigate disadvantages for relatively young children. Given the large empirical literature on school entry age and the disadvantages for young children, these results on the effects of mandatory school entrance screenings are also important for education systems on an international level. As standardization and data availability of the screenings proceed within the German federal states, new data might become available for future research to study the benefits of more flexible school entry regulations in greater detail.

Regarding the recent trends in the German higher education system, university rankings seem to be important if they provide new information within the application process. The results regarding the different ranking indicators suggest that this rather applies to the non-research dimensions than to the research-related indicators. This is plausible as research quality seems to be common knowledge within the group of high-ability students. In this case, the research-related ranking indicators do not provide any additional information. Note, however, that the different quality indicators influence prospective students' university choice only to a moderate extent. Distance between a student's hometown and the university remains the most powerful determinant of university choice in Germany. Thus, in future research it will be interesting to investigate whether the latest changes towards more competition within the German (European) higher education sector might increase the mobility of prospective students.

Drawing a final conclusion with respect to the Bologna Process or the different university admission procedures is more difficult. The estimated short-run effects of the Bachelor introduction suggest that especially students in the well-recognized German field of engineering avoid the new degree because the traditional German engineering degrees have a very good reputation. For a solid long-run evaluation of the Bologna Process, however, more research is needed at a later point in time when the traditional and the Bachelor degree system do not coexist any longer. During the time for which data is currently available, it was still possible to avoid the new Bachelor degree by opting into a traditional program. Furthermore, the number of students that can be observed in Master programs are still low. Therefore, a comprehensive evaluation of the Bologna Process is not possible at this point in time because the transformation process has not been completed.

My analyses of the decentralization of university admission represent a first attempt to provide empirical evidence using a natural experiment in university admission. The study evidences an increasing matching efficiency for the change from a centralized to a decentralized university admission procedure, which is mainly driven by enabling universities to abolish admission restrictions. This result may be very specific to the German context, though. As admission procedures vary substantially between countries and have been restructured over time in several countries, further research exploiting natural experiments in university admission may add to a more complete picture of the optimal admission process. The efficiency of different admission procedures is an important topic for the future because discussions on the most preferable admission practice are currently ongoing in several countries.

The latest wave of reforms succeeding the international student assessments, on which my thesis focusses, differs from the earlier reform processes in so far as the changes in the institutional setting are now accompanied by evaluation studies following modern empirical research strategies. Such evaluation studies allow to assess the effects of a reform on the (individual) student performance. Hence, they can support more profound and evidence-based school policy decisions. The advantage of studies exploiting natural experiments as opposed to international comparisons is that they compare situations within a very specific institutional setting with the same national peculiarities.

It is therefore desirable to already think of the evaluation of a reform at the time of implementing an institutional reorganization. However, this must not lead to even more reforms within an even shorter period of time. Rather, the opposite is advisable: reforms need time to develop their long-run effects, and researchers need time and data to solidly analyze the reform process. Therefore, researchers and politicians should work in unison in order to understand what fosters and what harms the efficiency of the education system. Politicians may serve this aim by taking the time until a reform is completely implemented and has unfolded its long-run effects before introducing even new activities. Researchers in the field of policy evaluation, on their part, must avoid being too much driven by short-run political interests.

Ultimately, this thesis does not only provide new evidence with respect to certain aspects of education but has also promoted my personal education.