DISCUSSION PAPER SERIES

IZA DP No. 10201

Effects of the Bologna Reform on Educational Outcomes: Micro Evidence from Germany

Sabrina Hahm
Jochen Kluve

September 2016

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

Effects of the Bologna Reform on Educational Outcomes: Micro Evidence from Germany

Sabrina Hahm
Humboldt-Universität zu Berlin

Jochen Kluve
Humboldt-Universität zu Berlin,
RWI and IZA

Discussion Paper No. 10201
September 2016

IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

IZA Discussion Paper No. 10201
September 2016

ABSTRACT

Effects of the Bologna Reform on Educational Outcomes: Micro Evidence from Germany*

The Bologna Process aimed at harmonizing European higher education systems and at increasing their efficiency. This paper analyzes impacts of the Bologna Reform for Germany by using unique micro data from Humboldt-Universität zu Berlin (HU). We estimate treatment effects on the probability to graduate within instructional time, on standardized study duration, and on final overall grades. Variation in treatment introduction over time and across departments generates exogenous assignment of students into a treatment (Bachelor) and control group (Diploma). We account for potentially remaining selection bias by estimating a 2SLS model using the share of first-year Bachelor students among all students as an instrument. Our empirical results are robust across specifications and sample stratifications and indicate the following: the Bologna reform led to a significant and sizeable increase in the probability of graduating within planned instructional time; it also significantly decreased standardized study duration. At the same time, overall final grades are significantly worse in the treatment group.

JEL Classification: I21, I28, J24

Keywords: Bologna process, education policy, university reform, impact analysis, instrumental variables

Corresponding author:

Jochen Kluve
Humboldt-Universität zu Berlin
School of Business and Economics
Spandauer Str. 1
10178 Berlin
Germany
E-mail: jochen.kluve@hu-berlin.de

* We gratefully acknowledge helpful comments by Carlo Barone, Maresa Sprietsma, Marcus Tamm, Meike Weltin and seminar participants at the Berlin Network of Labor Market Research (BeNA), RWI, the EU Joint Research Centre, Ispra (Italy), the Annual BAGSS Conference and the bologna.lab at Humboldt-Universität. All remaining errors are our own. We also gratefully acknowledge use of the Stata/LaTex framework provided by von Gaudecker [2014].

1 Introduction

A central goal of the European Community was the creation of a common market for goods, services, capital and labor. However, establishing common markets usually requires common standards. In order to create these European standards with respect to the labor market, in 1999 the EU member states met in Bologna, Italy, to agree upon the creation of a common higher education area. This meeting initiated a harmonization process, the goals of which were improved international competitiveness of the European higher education system, increased mobility among university staff and students as well as the enhancement of students' employability.

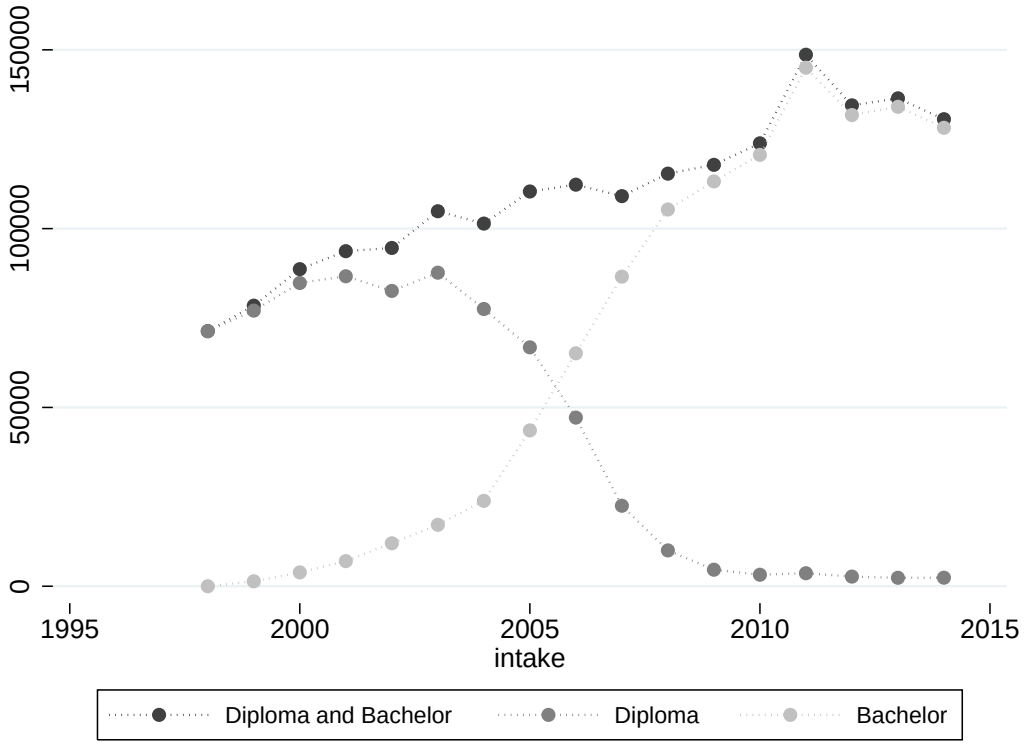
In order to implement the requirements of the Bologna Process over the next years all member countries had to adapt their education systems in accordance with a two-tier system consisting of an undergraduate level (Bachelor) and a graduate level (Master). In Germany the transformation from the traditional and renowned Diploma system to the new degree structure was highly controversial (De Rudder [2010]) and went on for almost a decade: specifically, Figure 1 displays the number of first-year students in Germany by degree type and shows that the main transition period lasted from the year 2000 until 2010.[1]

One argument for switching from comprehensive single-tier degrees (Diploma and Magister) to shorter Bachelor degrees was to increase efficiency of the higher education system. As the implementation of the Bologna Reform tied up substantial resources, the crucial question is whether the political goal of providing the labor market with university graduates within a shorter period of time was reached by the institutional adjustments undertaken in Germany.

Analyzing this question at the federal level is not possible due to a lack of student panel data. For this reason, previous analyses of the Bologna transition process in Germany focused on the aggregate level (e.g. Horstschräer and Sprietsma [2015]). To the best of our knowledge, our analysis is the first to investigate the reform success at the individual level by using micro data from Humboldt-Universität zu Berlin (HU). The data provide a key basis for investigating effects of the Bologna Process for a number of reasons. First, HU is one of the largest universities in Germany, so we are able to observe more than 24,000 students from

[1] This end point of the transition process corresponds to the deadline set by the joint declaration of the European ministers of education (Bologna Declaration [1999]).

Figure 1: Number of first-year students in Germany by degree, 1998 - 2014



Source: German Statistical Office, Series on enrollment in Tertiary Education, several volumes (Genesis-Online, table code 21311-0013)

the 1990s onwards. Second, this sample is homogenous over time, as we will show. Third, our data cover also many important dimensions of student heterogeneity, such as a broad set of subject choices and geographical origin of the pre-university education. Fourth, and most importantly, the sequential implementation of the reform at the department level generates exogenous variation to identify the Bologna Reform treatment effect.

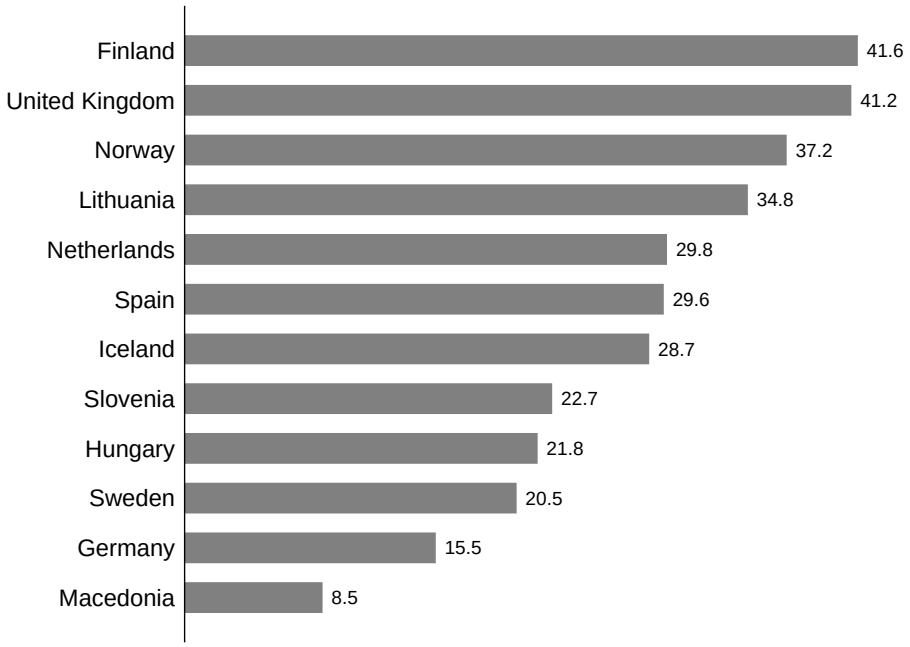
In the next section we give an introduction to the economic implications of the Bologna Reform. Section three provides an overview of the related literature on the evaluation of the Bologna Process. In the fourth section we introduce our data and present a descriptive analysis. Section 5 discusses identification - i.e. the Bologna reform as a natural experiment and IV estimation - and presents empirical estimates of the causal effect of the Bologna Reform on students' educational outcomes. Section 6 concludes.

2 Economic dimension and labor market relevance

During the 20th century higher education systems throughout Europe faced a vast expansion. While structural change was the driving force behind the increased demand for skilled labor in the whole industrialized world, the way in which this demand was satisfied differed across countries. In Germany, the well-established apprenticeship system ensured that the majority of the workforce was trained at a competitive level, while in other countries almost all post-secondary education was provided by higher education institutions. The heterogeneity in educational systems, on the one hand, led to differing shares of university graduates across countries, impeding international comparability of the population's skill levels. This is illustrated in Figure 2. On the other hand it caused problems concerning the international recognition of qualification levels and hindered the free movement of labor as one of the cornerstones of European integration. In order to fully exploit the academic and economic potential of the European higher education institutions, in 1998 Germany, France, Italy and the UK signed the Sorbonne declaration, in which they officially committed to striving towards structural compatibility and cooperation among European universities in order to promote mobility and international competitiveness. Only one year later, 30 countries signed the Bologna declaration which formally stated the goal of creating a common European higher education area (EHEA) by 2010. Currently (2016), the EHEA comprises 48 countries.

In addition to the goals stated at supranational level, for some of the signatories the Bologna Process was associated with several accompanying reforms. In particular Germany and Italy wanted to use the introduction of a two-tier higher education system to increase the efficiency of their higher education systems. In Germany, besides high dropout rates the problem of relatively long study durations was heavily discussed throughout the 1990s (see Destatis [1995]). In 1999, the median German university graduate studied 12 semesters and was 28 years old when attaining the first university degree (see Destatis [2003]). Due to demographic change and baby boomer retirement these comparatively long educational periods in life were expected to cause shortages of skilled labor as well as problems for social security systems. Hence, a substitution of the comprehensive traditional degrees by two separate and relatively short study periods was supposed to significantly reduce the age at which university graduates enter the labor market.

Figure 2: Tertiary education graduates (ISCED 5-6) aged 20-29 per 1 000 of the corresponding age population, selected European countries in 1998



Source: Eurostat

From the individual's perspective the introduction of Bachelor degrees effectively offered school graduates a choice of an alternative educational level. Before the Bologna reform secondary school graduates could basically choose between a practically oriented three-year apprenticeship or four- to five-year programs of scientific university education. The rather labor market focused Bachelor degree nowadays offers students a third way by getting some university education, but allowing them to enter the labor market after this short period of tertiary education, if they do not want to pursue one of the more research-oriented Master's programs.

According to human capital theory, the reduction of the regular study duration to six semesters reduces students' direct and indirect cost of obtaining a first university degree (Bachelor). Thus, ceteris paribus lower costs might for example reduce the pressure to work while studying and allow more students to focus on their academic obligations, which might have a positive effect on their educational outcomes. At the same time, the reform introduced a second type of university degree (Master), and the relative value of investing in either of the two relative to the old system (Diploma) is not clear a priori. Considering the potential channels and mech-

anisms of costs and return on investment therefore does not yield straightforward predictions of the impact of the Bologna Reform on students' educational outcomes (in particular study duration). We intend to answer this question empirically in the paper.

In the context of asymmetric information about employees quality, the new educational level also yields a more differentiated signal for graduates' quality (Bratti, Staffolani, and Broccolini [2006]). Therefore Bachelor students might have a stronger incentive to graduate compared to Diploma students because taking advantage of the Sheepskin effect is less costly for fewer years of education (Horstschräer and Sprietsma [2015]).

Since some of the Bachelor graduates do not want to attain a Master's degree, from a macroeconomic perspective the distinction between two cycles in higher education can reduce the cost of education per university graduate. This could allow more students to get access to higher education and eventually lead to a larger share of university graduates in the population. Consequently, the Bologna Reform could improve Germany's position in international OECD comparisons on the skill level of the workforce. However, whether this desired effect can actually be realized by the reform crucially depends on students' individual reaction to the new institutional framework.

3 Related work

Due to the recentness of the reform, so far there are rather few empirical economic studies on the effects of the Bologna Reform on the higher education system, and especially student performance. To date, many studies have been produced that look at the broader political and administrative changes and implications of the Bologna process, both from an international point of view (e.g Crosier and Parveva [2013], OECD [2011], Voegtle, Knill, and Dobbins [2011], Heinze and Knill [2008]) and from national perspectives (e.g. Suchanek et al. [2012] for Germany). Several authors focus on demand-side effects by analyzing enrollment rates, e.g. Cardoso et al. [2008] who find an increased demand for higher education in Portugal. A theoretical contribution by Mechtenberg and Strausz [2008] analyzes how student mobility induced by Bologna affects multi-cultural skills and quality of universities; Agasisti and Bolli [2013] test some implications of the model and - using data from Switzerland - find that the

Bologna reform appears to have enhanced university productivity.

As student drop out played a particularly important role in Italy before the reform, most of the literature about the reform effects on the efficiency of tertiary education is based on Italian data (e.g. Boero, Laurenti, and Naylor [2005]). This thematic focus is congruent with a long-standing line of educational research analyzing drop-out from higher education and its determinants (e.g. Bean [1980], Arulampalam, Naylor, and Smith [2004], Araque, Roldán, and Salguero [2009]). Specifically analyzing the Bologna reform, Cappellari and Lucifora [2009] use individual survey data to conduct a before-after-comparison for school graduates of 1998 and 2001 in Italy and find a significantly higher enrollment probability and a small negative impact on university drop out induced by the new degree structure. D'Hombres [2007] extends the concept of dropout by including inactive students in the definition. Her results indicate a decrease in drop-out / inactivity probability between 2.5 and 5.7 percent due to the reform. Pietro and Cutillo [2008] use Oaxaca-Blinder decomposition techniques to disentangle the effect due to students' behavioral change from the student composition effect of the reform. Their results suggest that even when controlling for changing characteristics of the student body there remains a negative effect of the reform on student drop-out.

Data on quantitative student performance indicators in Germany are mainly provided by the Federal Statistical Office (Destatis) and the German Centre for Higher Education Research and Science Studies (DZHW). While Destatis calculates aggregate graduation rates for student cohorts ten years after enrollment based on administrative cross-sectional data, DZHW administers its own student survey panel and combines it with Destatis data to compute dropout rates. A first analysis of student dropout in the context of the Bologna Reform for Germany was done by Horstschräer and Sprietsma [2015]. Using Destatis' administrative student data they analyze enrollment rates and conduct drop out analyses via cohort size comparisons, but do not find any significant effects of the reform. However, the identification of causal effects at the aggregate level is complicated by the fact that students frequently switch universities, but that after switching their treatment status may not remain constant.[2] To the best of our knowledge, for the German higher education system there does not yet exist any empirical

[2]This is because in contrast to some of their international counterparts, German universities could decide individually at the department level about the exact time of introduction of the new two-tier degree structure. This causes the aggregate ten-year timeline of the Bologna process displayed in figure 1. At the micro level, we can use this variation to identify treatment effects; see the subsequent discussion.

evidence based on administrative micro data allowing for identification of behavioral changes at the individual level.

Thus, our paper contributes to the identification of student's actual behavioral response to the Bologna Reform efforts. The focus on a specific university yields two main advantages. First, given an overall rather loose and unspecified regulatory framework and timeline of the reform process, a homogenous institutional framework within the university allows to pin down the precise content and timing of treatment. Second, the possibility to observe longitudinally whether a student who started a program is still part of the cohort in subsequent years, allows for an actual identification of effects at the micro level.

In contrast to other authors, we do not consider enrollment rates, as we believe they only have a limited explanatory power with respect to demand for higher education. Considering enrollment status as a demand indicator does not account for the fact that in many cases study capacities are limited and measuring enrollment only takes the market clearing result of supply and demand for higher education into account. Consequently, if there is excess demand for university education, relaxing the capacity constraint directly leads to a higher number of students - independent of the program's attractiveness.[3]

In accordance with the reform's objectives, we focus on the labor market relevant aspects of the reform. Our main interest lies in addressing whether the reform affected the capacity of the higher education system to provide the labor market with appropriately skilled university graduates within an adequate - i.e. now shorter - amount of time.[4] We address this objective in several dimensions using the following main outcomes: first, the analysis concentrates on graduation rates. In order to take into account the changes from the Diploma-based to the Bachelor-based system, we normalize graduation rates to occur within the respective regular instructional time (by degree program and subject of study). Second, we estimate treatment effects on standardized study duration (see detailed explanation in the next section). Third, the analysis assesses impacts on final overall grades. In addition to addressing the degree of

[3]One might argue that increased capacity is part of the reform itself, but in our data the introduction of the new degree structure and the increase in program capacities do not coincide: specifically, figure 3 in the next section indicates that the overall number of students in the relevant degree programs did not increase.

[4]We are aware that Diploma and Bachelor degrees differ in several respects, but from a policy perspective it is of key relevance to compare the two pathways to the first labor market qualifying tertiary degree in the old and new system.

attaining reform objectives, the empirical analysis therefore covers relevant individual-level outcomes that have so far received little attention in the empirical literature on the Bologna refom impacts.

4 Data and descriptive analysis

The data contain anonymized information about HU students from the beginning of the 1990s to March 2015. Since HU, being located in East Berlin, underwent a transition process in the first years after German reunification, we use data from winter term 1997 onward. We exclude the very recent student intakes from 2012 onward, since their regular instructional time would not fit in the observation period. We observe a total of 15 student cohorts (intakes 1997 to 2011). We include all degree programs that exist in both a pre Bologna variant (Diploma) and a post Bologna variant (Bachelor).[5] The final data contain observations for 24,675 students in 15 different subjects awarding single honors Diploma and Bachelor degrees.

Figure 3 depicts the time line of the implementation of the Bologna Reform at the subject level. Analogous to the process in the whole of Germany (recall figure 1), putting into practice the Bologna reform at HU took almost a decade. Figure 4 presents the distribution of the resulting absolute numbers of first-year Diploma and Bachelor students over time. The figure shows a - transitory - reduction in the overall number of first-year students during the second half of the 2000s.[6]

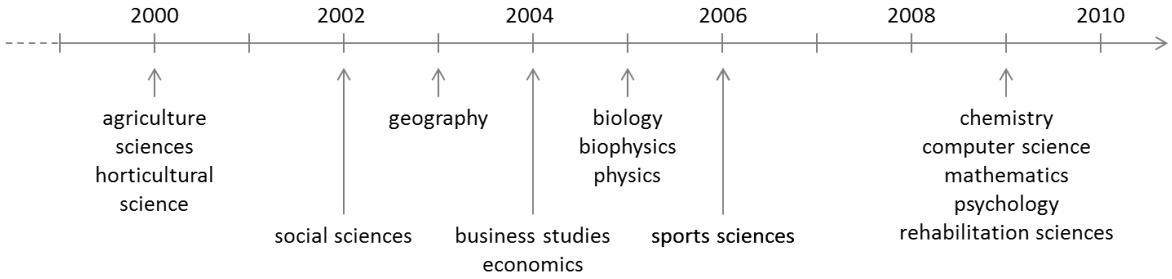
4.1 Descriptive statistics

The data comprise students' individual characteristics, information on programs studied at HU, study duration, graduation status, and final grades. Given legal regulations of this type of administrative data in Germany, no additional information on family characteristics such

[5] This excludes e.g. degree programs that were discontinued with the introduction of Bologna, or newly introduced. It also excludes joint honors degrees, since treatment status would be unclear whenever a student is enrolled in a joint program offered across two departments that did not implement the reform at the same point in time. For the few cases of students with multiple study spells, we consider the first spell only.

[6] This pattern likely results from the fact that departments' teaching capacities, which were formerly attributed exclusively to Diploma students, are now allocated among courses for Bachelor and Master students. From the year 2010 onwards, approximately, additional public funding has allowed universities to cope with the persistently higher numbers of students.

Figure 3: Coming-into-effect of the Bologna reform treatment at HU departments



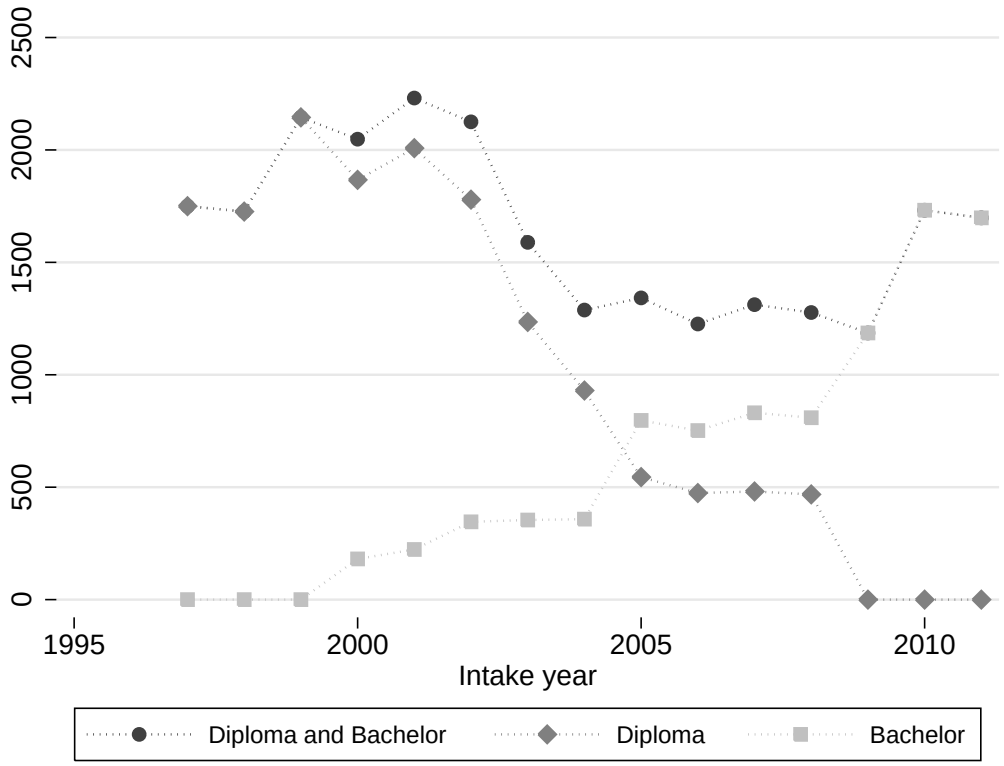
Source: Authors' illustration based on HU student statistics

as parents' educational or financial background can be contained in the data. Whereas this limits our set of potential control variables, the data do contain key background information at the individual student level. Note also that our data encompass the population of HU students. Table 1 provides the list of variables and their means for Diploma (N=15,408) and Bachelor (N=9,267) students. As most variables are indicator variables, averages correspond to the share of Diploma or Bachelor students belonging to the respective group.

The first panel describes student characteristics at the time of enrollment. Notably, the mean enrollment age and the time span between secondary school graduation and university entrance are almost identical for both groups. As mentioned above, cohort sizes in Bachelor programs were smaller compared to Diploma programs, so the mean values for cohort sizes differ significantly. Slight differences in the share of female students in the sample arise from the fact that we observe more Diploma than Bachelor students - particularly for those subjects that are more popular among male students (e.g. math, computer science and chemistry). The share of students starting their academic career at HU ('first-time enrollers') remained relatively unaltered by the reform, so there is no indication that there might be significantly more experienced first-year students in one or the other group.[7]

[7] Note that throughout our analysis we consider those students who start a program in the first semester, in order to make sure that students did not change treatment status by switching universities, and to correctly compute their study duration. This includes all first-time enrollers, and also those first-semester students who already studied in another program at HU or elsewhere before.

Figure 4: Number of first-year students at HU by degree, 1997 - 2011



Source: HU student statistics

The variables in the second panel of Table 1 describe the geographical origin of students' higher education entrance certificates. For almost all of the federal states except for Berlin, we find essentially identical shares in the Bachelor and Diploma subsample. At the same time, the share of students with foreign university entrance certificate among Diploma students was about 5.9 percent, while among Bachelor students 9.3 percent received secondary schooling abroad. This may point to an increased international mobility in higher education which was intended by the Bologna Reform. The further decrease of the (small) share of unknown geographical origin results from improved HU student statistics.

Table 1: Summary statistics

Variable	Diploma	Bachelor
Student characteristics		
Intake age	23.03	22.94
Months since high school graduation	90.82	83.71
Size of intake cohort	175.9	126.4
Female (percent)	47.3	50
First-time enroller (percent)	70.2	72.4
Geographical origin of pre-university education (percent)		
Bavaria	2.3	3.1
Brandenburg	12.5	13.4
Berlin	48.9	43.4
Bremen	0.6	0.6
Baden Wurttemberg	3.8	4.3
Hamburg	0.9	1.2
Hessen	2.3	2.6
Mecklenburg-West Pomerania	3.1	3.2
Lower Saxony	3.4	4.0
North Rhine Westphalia	4.8	5.7
Rhineland Palatinate	0.9	1.1
Saarland	0.2	0.2
Schleswig-Holstein	1.1	1.6
Saxony	2.3	2.1
Saxony Anhalt	2.3	2.2
Thuringia	1.4	1.5
Foreign university entrance certificate	5.9	9.3
Unknown	3.5	0.8
Student outcomes		
Duration of studies (semesters)	12.78	7.24
Duration of studies (index)	1.49	1.27
Program graduate (percent)	32.7	33.9
Graduation within planned instructional time (percent)	2.17	15.8
Still enrolled (percent)	3.28	14.6
Final grade	1.91	2.19
Number of students in sample	15,408	9,267
Number of graduates in sample	5,045	3,141

Table entries are sample averages.

The last panel in Table 1 presents mean values for various student outcome variables. First, Bachelor graduates have been substantially faster than their Diploma counterparts: looking at the average duration of studies reveals that Diploma graduates took 12.8 semesters, while Bachelor graduates required 7.2 semesters to finish their program.[8] This illustrates that the reform was successfully implemented in line with its objective to reduce study duration; the

[8]Note that the averages reflect the "active" number of semesters studied, excluding times during which students suspended their student status (e.g. in order to do an internship or study abroad).

significant reduction also reflects the generally shorter curricula of the Bachelor versus the Diploma programs, since post-Bologna some contents of the curricula of Diploma programs would be shifted to the Master programs.

However, our data allow us to calculate an even more precise measure of duration based on exact enrollment and final examination dates. By computing the difference between the two dates (in days) and dividing by the regular instructional time of the particular program, we obtain a standardized study duration of Diploma and Bachelor students in continuous time. If the index takes on the value 1 for a given person, this indicates that the actual time spent studying equals the regular instructional time determined by the program. The index thus measures the ratio between the actual educational lifetime dedicated to graduating from a given program relative to the planned time this is supposed to take according to program regulations. Table 1 shows that, according to this index, both the pre-Bologna and post-Bologna groups on average take longer than the planned instructional time to graduate, with index values of 1.49 and 1.27, respectively. That is, while Bachelor students extend the planned time-to-graduation by an average of about 25 per cent, Diploma students do so by almost 50 per cent, with a difference in average prolongation between the two groups of 22 percentage points.

In addition to looking at mean differences in study duration, Figure 5 presents the frequency distribution of time-to-graduation in semesters for Bachelor and Diploma students. The figure shows a strong clustering of Bachelor graduates at a duration of six semesters, while for Diploma students the distribution peaks at eleven semesters. A relatively large fraction of Diploma students graduates within ten semesters, but a very small fraction finishes within nine semesters, which is the planned instructional time for most of the Diploma students.[9] Planned instructional time generally amounts to six semesters for Bachelor students. Figure 6 plots the frequency distribution for the standardized duration index and shows that the fraction of students finishing in or even before instructional time is larger for Bachelor students, while the fraction of students taking longer is always higher for Diploma students. Taken together, the findings from these figures indicate that the time needed for graduation has decreased

[9]Regular instructional time varies at the department level. While biology, physics and biophysics had an instructional time of ten semester, Diploma students in economics, business and sports science were expected to graduate within eight semesters.

significantly for post-Bologna students - both in absolute and relative terms.

Besides the study duration, student outcomes in Table 1 (bottom panel) show that the share of graduates comprises about a third of students in the data for both Diploma and Bachelor programs (32.7 and 33.9 per cent, respectively).[10] When combining this information with planned study duration, almost half of the Bachelor graduates (16 percent of all post-Bologna students in the data) studied for a maximum of six semesters, but among Diploma graduates only about every fifteenth student managed to graduate within regular instructional time (2.2 percent of all pre-Bologna students). Whereas almost 15 percent of the Bachelor students in our data are still enrolled, this is the case for 3.3 percent of Diploma students. Bachelor students' final grades - given by a scale ranging from 1.0 (best) to 4.0 (lowest non-failing grade) - turn out to be worse on average compared to Diploma students' grades by 0.3 grade points (1.9 vs. 2.2).

4.2 Analysis of outcome dynamics

Before assessing the quantitative effects of the Bologna Reform on outcome variables, it is interesting to investigate how the outcome variables for the treated population evolve over time, and whether there is some movement in these variables around the discontinuity, i.e. the point(s) in time of introduction of the reform.

Let Y denote the outcome variable in general. The introduction of the new degree structure in the different subjects occurred at one of seven different points in time, i.e. in the years 2000, 2002, 2003, 2004, 2005, 2006 or 2009 (recall Figure 3). Hence, for every subject we observe at least three cohorts before treatment and three cohorts succeeding treatment, depending on the precise year when the reform was introduced. Consequently, we observe a larger number of cohorts with Diploma students for a subject that introduced the Bachelor later, and vice versa.

We can use this information to investigate the dynamics in outcome variables at the discontinuity in the following way: Let t denote the number of cohorts since treatment - i.e. the

[10] Note that these shares represent subject-specific retention rates; i.e. the probability that a student graduates from the one particular university program that he or she started, and not whether he or she graduated at all (perhaps after switching subjects one or several times).

Figure 5: Absolute duration of studies for program graduates in semesters (discrete values)

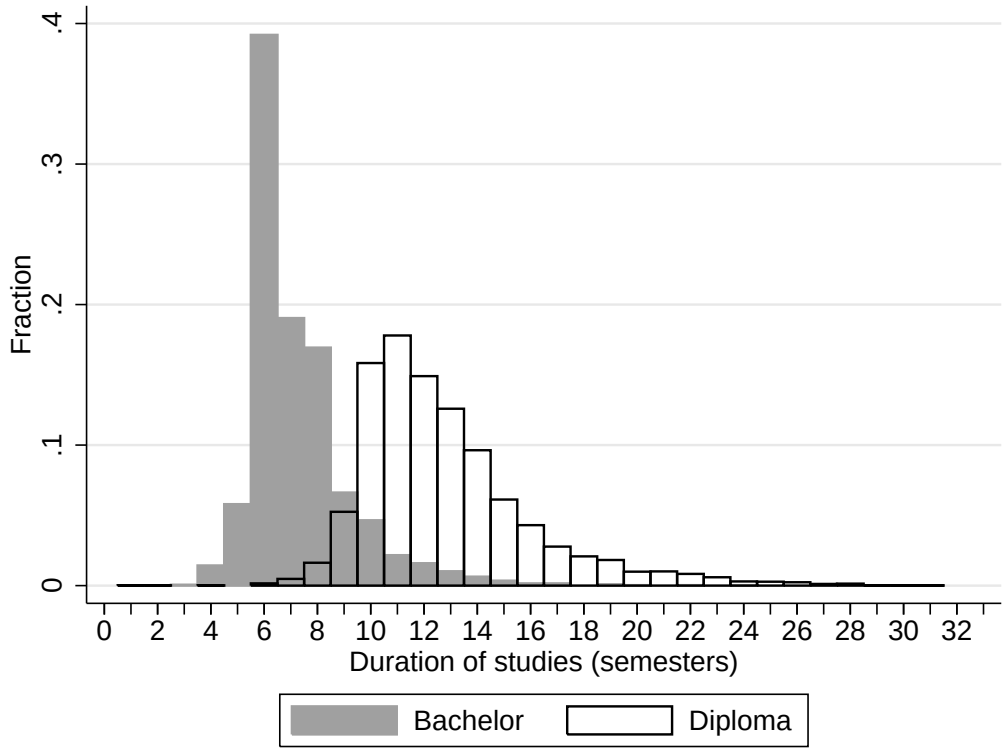
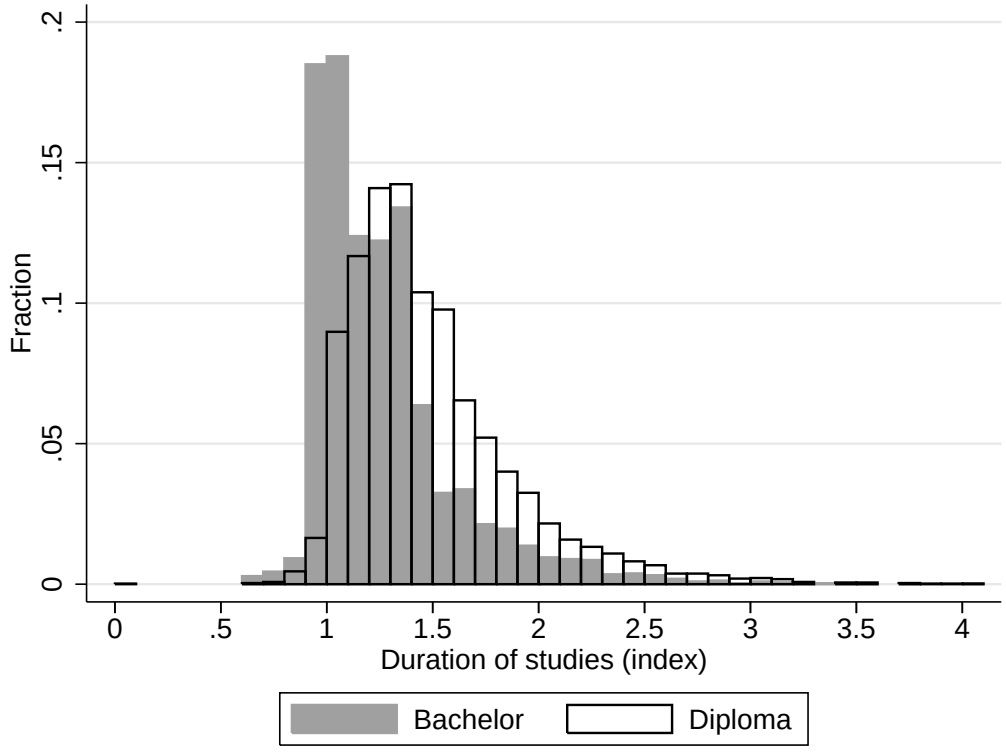


Figure 6: Standardized index: duration of studies for program graduates relative to regular instructional time (continuous values)



Bologna Reform being put into practice at the departmental level - occurred. If t is negative, the treatment occurs -t cohorts later. Treatment is standardized to occur at $t = 0$ for all subjects - independent of the specific year of Bachelor introduction in real time. If there are k data cohorts, then there are observations for $t \in [-(k-3), (k-4)]$. In order to indicate whether an individual is observed in t we define a set of $2(k-1)$ dummy variables D_{id}^t, where id is a subscript denoting that student i is enrolled in degree program d with d $\in$ {Diploma, Bachelor}. The average value of the outcome variable at point in time t can then be calculated as

$$\hat{Y_d^t} = \frac{1}{N_d^t} \sum_i (D_{id}^t Y_i^t), \tag{1}$$

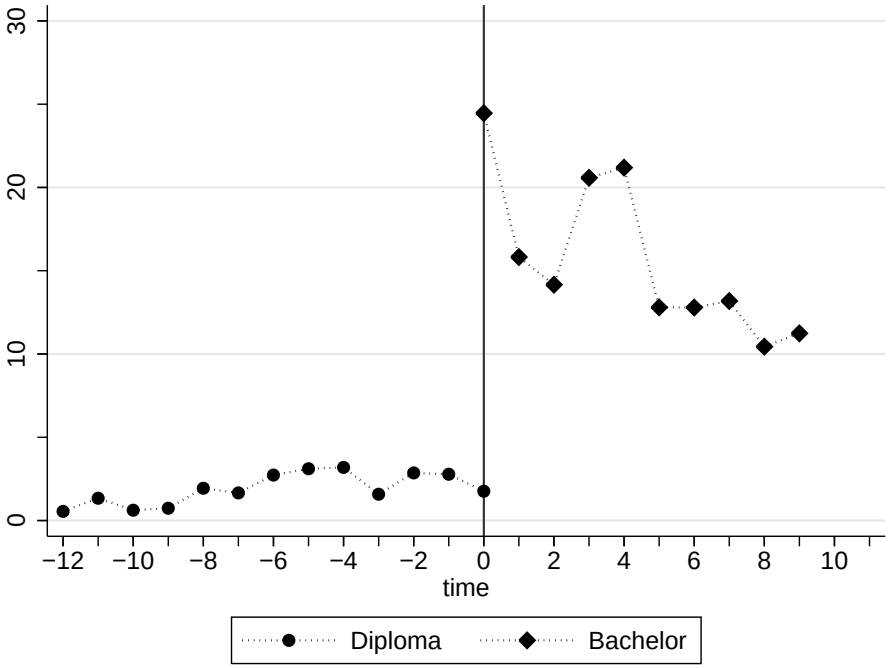
where N_d^t is the number of students for which $D_{id}^t = 1$. Using $d \in$ {Diploma, Bachelor} in this equation is necessary, since for three subjects (economics, business, geography) at time t=0 both a Diploma and a Bachelor cohort exist.

Note that the closer we move towards t=0 from both sides, the more precise our computations become, because the number of students as well as the subject set contributing to the average outcomes increases. Specifically, for $t \in [-3, 2]$ we observe the population of students from all subjects of study. In order to not give too much weight to single fields of study, we calculate equation (1) only for cohorts comprising students from at least three subjects.

Figures 7 through 10 present the results from these computations, depicting the outcome dynamics around treatment introduction for four outcomes: (a) the probability to graduate within planned instructional time (Figure 7), (b) the absolute duration of studies in semesters (Figure 8), (c) the standardized duration index introduced above that measures the ratio between actual educational lifetime dedicated to graduating relative to the planned instructional time according to regulations (Figure 9), and (d) the final overall grade at graduation (Figure 10).

All four figures indicate a visible discontinuity in the outcome variables occurring with treatment introduction, along with persistent patterns before and after time t=0. For three of the outcomes (probability to graduate within planned time, duration in semesters, standardized duration index) the respective discontinuities are very pronounced. Clearly, in the case of the

Figure 7: Outcome dynamics around treatment introduction: Probability to graduate within regular instructional time



absolute duration (Figure 8) the large drop in the average duration could be expected theoretically given the switch from the longer Diploma programs to the shorter Bachelor programs, if the Bologna reform were to have been implemented as planned. This, therefore, seems to be the case. At the same time, both the large increase in the probability to graduate within planned time (Figure 7) and the drop also in the standardized duration index (Figure 9) are striking: specifically, the average probability to graduate within planned time rises from less than 5 per cent to approximately 15 per cent, and the average duration index decreases from about 1.5 to about 1.25, indicating that post-reform planned instructional time is on average exceeded by only about a quarter (as opposed to about one half pre-reform). Moreover, the corresponding figures show that the differences induced at time t=0 are persistent during the observed time periods of up to 12 years before and up to 9 years after treatment introduction.

Regarding the fourth outcome, final overall grade at graduation, Figure 10 shows that the discontinuity at time t=0 is less pronounced than for the other three outcomes; in particular, no immediate strong increase or decrease can be seen. Looking at the full time windows before and after treatment introduction, however, average final grades appear visibly lower

Figure 8: Outcome dynamics around treatment introduction: Absolute duration of studies

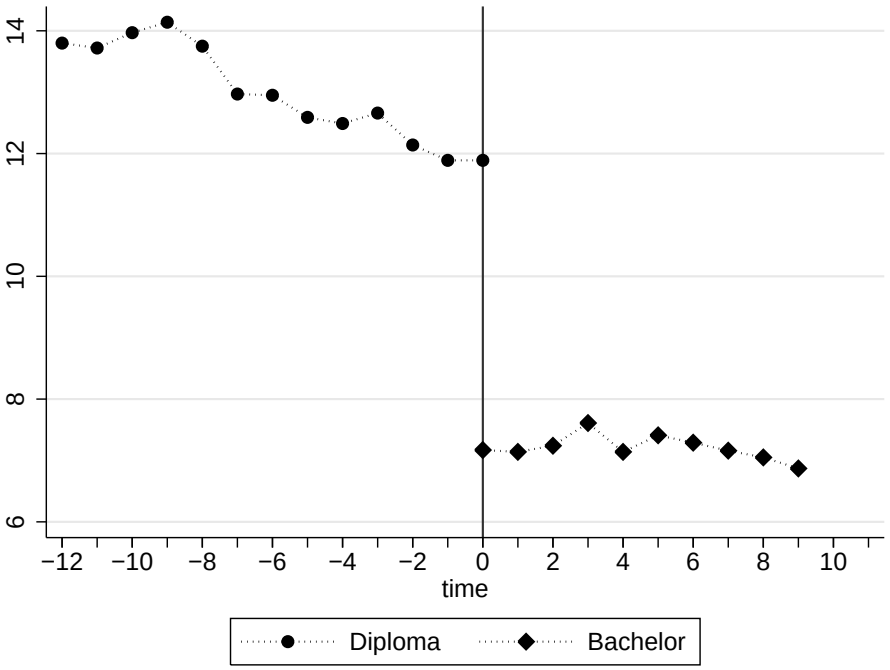


Figure 9: Outcome dynamics around treatment introduction: Duration index

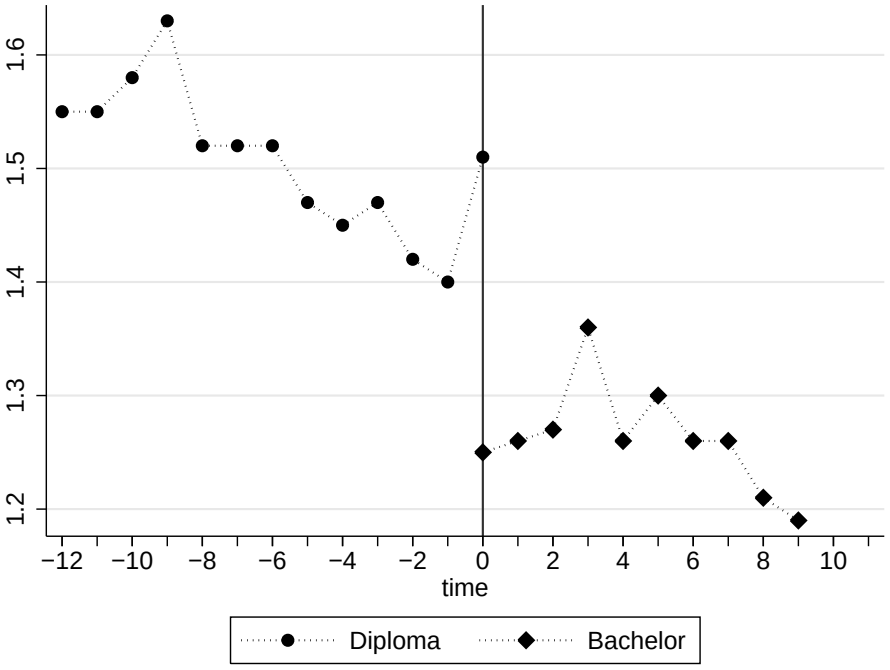
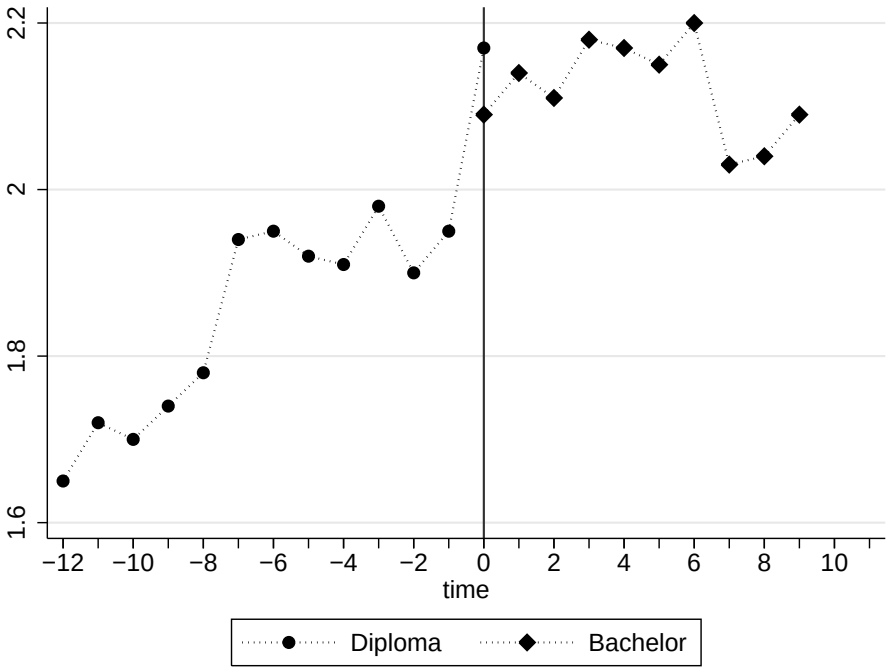


Figure 10: Outcome dynamics around treatment introduction: Final grade



- i.e. better - during the pre-Bologna period than during the post-Bologna period. The dynamic patterns in Figure 10 indicate some increase from an average of approximately 1.7 to approximately 1.9 moving towards the Bologna reform introduction, and an overall average final grade of about 2.1 during the time period afterwards. This would imply a noticeable deterioration in overall final grades after treatment introduction.

Statistical tests on the pronounced pre-post mean differences in Figures 7 - 10 show that for each of the four outcomes the difference is statistically significant. At the same time, when we conduct these graphical analyses for the covariates (e.g. gender, age, time since graduation from secondary school; omitted here for brevity but available upon request) the profiles are essentially flat.

5 Identification and empirical analysis

5.1 The Bologna reform as a natural experiment: OLS impact estimates

We are interested in estimating the causal effect of the Bologna reform on students' educational outcomes. In the first step of our empirical strategy we estimate the following equation

$$Y_i = \alpha + \beta Bologna_i + \gamma X_i + \delta_g + \theta_c + \tau_s + \epsilon_i. \tag{2}$$

Y_i denotes the outcome of interest. Specifically, we consider the probability of graduating within planned instructional time, the final overall grade, and the study duration index as outcomes. α is a constant, X_i a set of covariates, and β is the average treatment effect of implementing the Bologna reform, i.e. the parameter of interest. Delta denotes a state effect (geographic origin), θ is an intake effect (intake cohort), τ a subject effect (field of study), and ϵ_i the error term.

The identification strategy underlying this estimating equation is based on the idea that German universities (and also HU) effectively faced a continuum of university entrants during the relevant time period from 1997 to 2011. This continuum is constant in composition at different points in time, and was thus affected by the Bologna reform as an exogenous shock assigning students quasi-randomly to a treatment group (post-Bologna, i.e. Bachelor students) and a control group (pre-Bologna, i.e. Diploma students). The key identifying assumptions to make β an unbiased estimate of the Bologna reform impact are that (i) knowledge of the reform does not selectively affect young adults' choice to go to university or not (permanence of student intake over time), (ii) knowledge of the reform does not selectively affect the choice of university (permanence of geographical distribution of student intake over time), and (iii) knowledge of the reform and its time-varying implementation across university departments does not selectively affect the choice of field of study (permanence of subject choice).

There is evidence that these assumptions are satisfied. Regarding assumption (i), Figure A.1 in the appendix displays the distributions of university entrance certification grades (i.e. high-school grades) for several subjects of study and several years before and after the reform. Similarly, Figure A.2 shows the respective grade distributions for geography for the years 2005

and 2006, years in which the department admitted students to both types of degree programs. Both figures show that there are no changes in the grade distributions that would indicate any (self-)selection of more or less skilled students either before or after Bologna. Moreover, representative survey data collected by the federal student union ([Studentenwerk, 1997-2012]) show that there is no change in the educational composition of students' family background comparing the years 2000, 2003, 2006, 2009, and 2012. Regarding assumption (ii), the summary statistics in Table 1 show that the distribution of geographic origin effectively does not vary between the treatment (Bachelor) and control group (Diploma) samples. Regarding assumption (iii), Figures A.1 and A.2 also provide some tentative support, and in general it seems unlikely that students would have been able to make an informed strategic choice of subject, given the large variation in implementation time points across time, universities, and even across departments within universities. Taking this evidence together, it therefore seems plausible that the implementation time points - and thus the assignment to treatment and control group - are indeed exogenous to students' decisions.

In addition to the plausibility of the key identifying assumptions, a few potential threats to identification are important to be discussed in the given context. First, are there any simultaneous reforms that might affect students' outcomes and/or bias our impact estimates? Such reforms could be e.g. the secondary school reform reducing the mandatory number of years to qualify for university education from 9 to 8 years. Implementation of this so-called G8-Reform varied by federal state; within our sampling frame, only secondary school graduates from six of the 16 federal states were affected by the reform, and only during the most recent years (2008 onward). Since we control for intake age and cohort effects our estimates are unlikely to be affected by the small share of G8-graduates in our sample. We empirically test this in the robustness section. A second reform potentially affecting student intake cohorts is the discontinuation of compulsory military service in 2011. This, however, likely causes a time-shift in student intake only, but does not affect composition. Again we empirically test this by estimating impacts for women and men separately, since only men are affected by compulsory military service in Germany.

Finally, in order to make the treatment-control comparison of Bachelor vs. Diploma valid, consistency of the contents of the subjects of study is required; this requirement is satisfied, however, since despite a general and inevitable shortening of the contents, the core subjects

remained (largely) unchanged. While some departments at HU took the opportunity to restructure their programs using new course titles while keeping contents constant (e.g. computer science), other departments generally retained the same courses (e.g. economics).

Table 2: Estimated impact of the Bologna Reform on graduation within planned instructional time (OLS)

	(1)	(2)	(3)	(4)	(5)
Bologna	0.136***	0.127***	0.126***	0.154***	0.180***
	(0.0191)	(0.0195)	(0.0194)	(0.0311)	(0.0258)
Female		0.00284	0.00243	0.00232	0.000118
		(0.00861)	(0.00852)	(0.00851)	(0.00439)
Intake age		-0.00714***	-0.00643***	-0.00634***	-0.00608***
		(0.00128)	(0.00122)	(0.00124)	(0.00107)
Foreign university		-0.0221*	-0.0132	-0.0164	-0.0233**
entrance certificate		(0.0120)	(0.0124)	(0.0129)	(0.0108)
Months since high		0.0000609**	0.0000281	0.0000248	0.0000271
school graduation		(0.0000294)	(0.0000256)	(0.0000258)	(0.0000270)
Standardized intake		-0.00489***	-0.00483***	-0.00259**	0.000205
cohort size		(0.000997)	(0.000984)	(0.00112)	(0.00183)
Constant	0.0217***	0.189***	0.168***	0.161***	0.158***
	(0.00391)	(0.0337)	(0.0329)	(0.0340)	(0.0228)
State effects	No	No	Yes	Yes	Yes
Intake effects	No	No	No	Yes	Yes
Subject effects	No	No	No	No	Yes
Observations	24,675	24,675	24,675	24,675	24,675
Adjusted R^2	0.064	0.079	0.081	0.097	0.114

Standard errors in parentheses are clustered at the subject level.
* p < 0.1, ** p < 0.05, *** p < 0.01
"State effects" are indicator variables for high school diploma from the 16 federal states. "Intake effects" are indicator variables for the intake cohort. "Subject effects" are indicator variables for the field of study.

Table 2 reports OLS impact estimates for the probability of graduation within planned instructional time. The table reports the raw impact first (column 1), and subsequently adds the set of covariates (column 2), state effects for geographic origin (column 3), intake cohort effects (column 4), and finally subject of study effects for the full specification (column 5).

Table 3: Estimated impact of the Bologna Reform on study duration index (OLS)

	(1)	(2)	(3)	(4)	(5)
Bologna	-0.215***	-0.217***	-0.215***	-0.0336	-0.0901***
	(0.0457)	(0.0518)	(0.0513)	(0.0360)	(0.0205)
Female		-0.0383	-0.0379	-0.0404	-0.0263**
		(0.0328)	(0.0326)	(0.0320)	(0.0106)
Intake age		0.0158***	0.0153***	0.0135***	0.0107***
		(0.00374)	(0.00402)	(0.00329)	(0.00202)
Foreign university		0.0371	0.0287	0.0633*	0.0676**
entrance certificate		(0.0406)	(0.0437)	(0.0362)	(0.0327)
Months since high		-0.000168*	-0.000145	-0.000144	-0.000164*
school graduation		(0.0000860)	(0.0000933)	(0.0000926)	(0.0000867)
Standardized intake		-0.000630	-0.000820	-0.00796	-0.00689
cohort size		(0.0118)	(0.0119)	(0.0125)	(0.00468)
Constant	1.485***	1.170***	1.186***	1.306***	1.342***
	(0.0436)	(0.111)	(0.122)	(0.110)	(0.0637)
State effects	No	No	Yes	Yes	Yes
Intake effects	No	No	No	Yes	Yes
Subject effects	No	No	No	No	Yes
Observations	8,186	8,186	8,186	8,186	8,186
Adjusted R^2	0.071	0.084	0.084	0.141	0.242

Standard errors in parentheses are clustered at the subject level.
* p $<$ 0.1, ** p $<$ 0.05, *** p $<$ 0.01
See footnote Table 2.

This structure will also be used in the following three tables for the other three outcomes. In particular, Table 3 reports corresponding treatment effect estimates for the study duration index. This estimation can be implemented for those students who actually graduated. Given our sampling frame, the distribution of study durations in the control group (Diploma students pre-Bologna) necessarily contains a group with (very) long durations, but who still graduated, that cannot be captured for the treatment group. We therefore provide an additional estimate of the Bologna effect on the study duration index based on using, in addition, imputed durations (to be precise: imputed duration indices) for those Bachelor students who at the end of our sampling frame have not yet graduated, but are still enrolled. For the imputation, we use the Diploma sample and regress the study duration index for all graduates on the full set

of explanatory variables, then use the coefficients of the model to predict the study duration index for the full Bachelor sample. The impact estimation results using this larger sample with imputed data are reported in Table 4. Note that in using these two procedures the first one would tend to overestimate the treatment effect on duration (because the more "successful" graduates would be faster in graduating), whereas the second one likely represents a lower bound. Finally, Table 5 reports treatment effect estimates on overall final grades.

Table 4: Estimated impact of the Bologna Reform on study duration index using imputed data (OLS)

	(1)	(2)	(3)	(4)	(5)
Bologna	-0.218***	-0.238***	-0.237***	-0.0402	-0.0420***
	(0.0298)	(0.0303)	(0.0296)	(0.0382)	(0.0121)
Female		-0.0321	-0.0318	-0.0369	-0.0279***
		(0.0306)	(0.0304)	(0.0294)	(0.00630)
Intake age		0.0119***	0.0117***	0.0113***	0.00917***
		(0.00211)	(0.00237)	(0.00174)	(0.000913)
Foreign university entrance certificate		0.0725***	0.0666***	0.0818***	0.0809***
		(0.0199)	(0.0244)	(0.0208)	(0.0146)
Months since high school graduation		-0.000108**	-0.0000958	-0.0000971*	-0.000144***
		(0.0000512)	(0.0000585)	(0.0000575)	(0.0000344)
Standardized intake cohort size		-0.00837	-0.00840	-0.00604	-0.00173
		(0.00713)	(0.00716)	(0.00882)	(0.00201)
Constant	1.485***	1.251***	1.259***	1.351***	1.361***
	(0.0436)	(0.0833)	(0.0952)	(0.0843)	(0.0364)
State effects	No	No	Yes	Yes	Yes
Intake effects	No	No	No	Yes	Yes
Subject effects	No	No	No	No	Yes
Observations	14,312	14,312	14,312	14,312	14,312
Adjusted R^2	0.100	0.124	0.129	0.200	0.369

Standard errors in parentheses are clustered at the subject level.
* p $<$ 0.1, ** p $<$ 0.05, *** p $<$ 0.01
See footnote Table 2.

The estimates indicate significant effects of the Bologna reform on the outcomes considered. The coefficient on the treatment indicator remains significant for all specifications, and for some outcomes also varies very little in size. Specifically, we estimate an average treatment

Table 5: Estimated impact of the Bologna Reform on final grade (OLS)

	(1)	(2)	(3)	(4)	(5)
Bologna	0.234***	0.270***	0.283***	0.351***	0.230**
	(0.0842)	(0.0810)	(0.0786)	(0.0923)	(0.0902)
Female		0.000323	-0.00127	-0.000158	0.0107
		(0.0466)	(0.0472)	(0.0467)	(0.0133)
Intake age		0.0306***	0.0301***	0.0296***	0.0336***
		(0.00294)	(0.00312)	(0.00308)	(0.00286)
Foreign university		0.217***	0.191***	0.204***	0.122***
entrance certificate		(0.0517)	(0.0472)	(0.0430)	(0.0315)
Months since high		-0.000572***	-0.000499***	-0.000484***	-0.000538***
school graduation		(0.0000849)	(0.0000893)	(0.000102)	(0.000120)
Standardized intake		0.0366	0.0360	0.0354	0.00466
cohort size		(0.0260)	(0.0251)	(0.0278)	(0.0136)
Constant	1.902***	1.243***	1.270***	1.332***	1.657***
	(0.0990)	(0.116)	(0.126)	(0.140)	(0.0943)
State effects	No	No	Yes	Yes	Yes
Intake effects	No	No	No	Yes	Yes
Subject effects	No	No	No	No	Yes
Observations	8,163	8,163	8,163	8,163	8,163
Adjusted R^2	0.044	0.091	0.103	0.109	0.262

Standard errors in parentheses are clustered at the subject level.
* p $<$ 0.1, ** p $<$ 0.05, *** p $<$ 0.01
See footnote Table 2.

effect on the treated on the probability to graduate within planned instructional time of 18 percentage points (Table 2, column 5). Regarding the study duration (Tables 3 and 4) the size of the coefficients varies somewhat more strongly, but the full specifications (column 5 each) indicate a decrease in the standardized duration index in the range of -0.09 to -0.042 (for the samples without and with imputed data, respectively). Whereas the results for these outcomes - probability to graduate within planned time and study duration - indicate qualitatively positive effects of the Bologna reform, the impacts on overall final grades are qualitatively negative, as Table 5 shows: the point estimate of the average increase (i.e. worsening) in grades varies between 0.23 and 0.35, and coincides with the lower bound for the full specification. It implies a noticeable upward shift in the average final grade of HU graduates.

5.2 Instrumental variables estimates of the Bologna effect

The identification strategy in the previous section essentially considers treatment status as exogenous, because the status of being in a Diploma or Bachelor degree program is implicitly (and randomly) determined by the preceding individual choice about which subject and at which university to study. We argued that this set-up generates a natural experiment that allows to estimate unbiased estimates using simple linear regression. In a next step suppose that there are strong utility losses at the individual student level associated with the switch from a Diploma to a Bachelor's degree - e.g. due to long academic traditions at specific universities - and that these losses outweigh any city or university benefits, lower travel costs, etc. That is, consider a case in which some students do make a deliberate effort to "avoid treatment", which might render our treatment indicator in equation (2) endogenous. The potential success of this effort then depends on the number of available alternatives. Specifically, for instance, if all other universities except HU still offer Diploma degrees, avoidance of treatment is easy, and vice versa.

Following this logic, in a second step of our empirical analysis we instrument students' treatment status with the share of first-year Bachelor students among all first-year Bachelor and Diploma students for each subject of study and year. This instrumental variable is a direct measure of treatment probability, varying at the subject and intake group (cohort) level. It is arguably exogenous, since we would not expect this share to have any direct impact on students' educational outcomes other than through the endogenous regressor, i.e. being in a Bachelor or Diploma degree program. Figure 11 illustrates the instrument by displaying the timeline of the coming-into-effect of the Bologna reform in Germany by subject - as the share of first-year Bachelor students among all first-year students - and the specific time point at HU.[11] Correspondingly, Table 6 displays the first-stage results and shows that the instrumental variable is highly and significantly correlated with treatment status.

[11] Note that at the individual level the instrument takes on the particular value of the share determined by subject and year; not only the shares at the intersections of the two curves displayed in Figure 11.

Figure 11: Timeline of treatment introduction in Germany and at HU, by subject

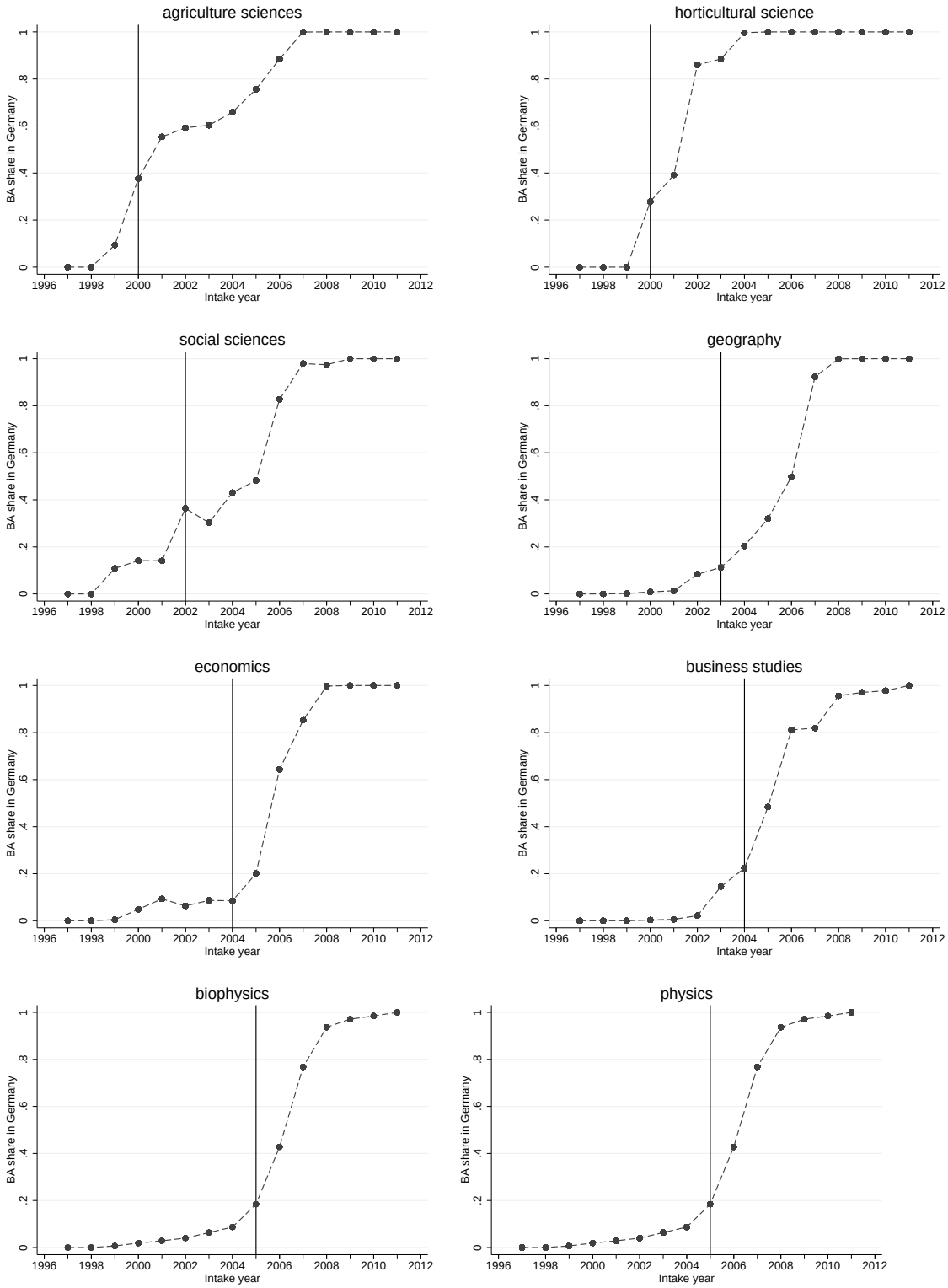
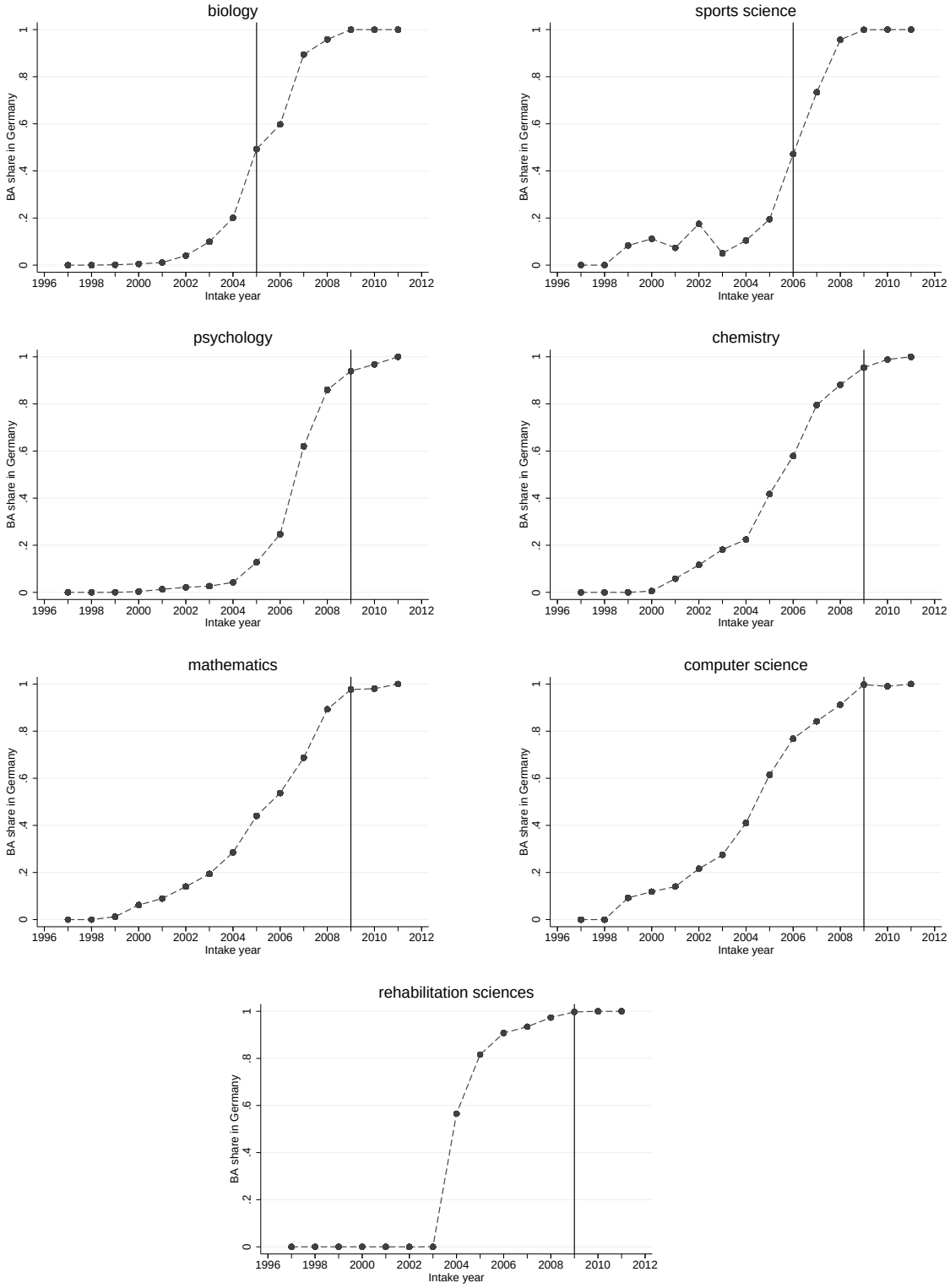


Figure 11 continued: Timeline of treatment introduction in Germany and at HU, by subject



The graphs display the respective annual share of first-year Bachelor students among all first-year students (Diploma and Bachelor) in Germany. The vertical lines indicate the respective coming-into-effect of Bologna at HU.

Table 6: First-stage regression

	(1) Bologna
Share of Bachelor first-year students	0.959***
	(0.0337)
Female	0.0177
	(0.0303)
Intake age	0.00127
	(0.00263)
Foreign university	0.0355*
entrance certificate	(0.0189)
Months since high	0.00000539
school graduation	(0.0000385)
Standardized intake	-0.00569
cohort size	(0.00394)
Constant	-0.0524
	(0.0849)
State effects	Yes
Observations	24,675
Adjusted R^2	0.691

Standard errors in parentheses are clustered at the subject level.
* p < 0.1, ** p < 0.05, *** p < 0.01

We estimate the following equation

$$Y_i = \alpha + \beta Bologna_i + \gamma X_i + \delta_g + \epsilon_i \tag{3}$$

using 2SLS, where the (potentially) endogenous treatment variable Bologna is instrumented using the exogenous variable Share (of first-year Bachelor students among all first-year students). Since the instrument varies at the intake cohort and subject level, cohort and subject effects are omitted from equation (3). Using the same four outcome variables of interest as above, Table 7 reports the corresponding IV estimates of the Bologna impact.

Table 7: Instrumental variables estimates of the impact of the Bologna Reform

	(1) In-time graduation	(2) Duration index	(3) Duration index imputed	(4) Final grade
Bologna	0.0983***	-0.307***	-0.323***	0.231***
	(0.0184)	(0.0621)	(0.0271)	(0.0853)
Female	0.00281	-0.0393	-0.0329	-0.00208
	(0.00871)	(0.0325)	(0.0305)	(0.0492)
Intake age	-0.00630***	0.0150***	0.0130***	0.0299***
	(0.00120)	(0.00447)	(0.00266)	(0.00324)
Foreign university entrance certificate	-0.00910	0.0534	0.0836***	0.205***
	(0.0108)	(0.0476)	(0.0273)	(0.0531)
Months since high school graduation	0.0000231	-0.000138	-0.0000905	-0.000494***
	(0.0000252)	(0.0000970)	(0.0000599)	(0.0000911)
Standardized intake cohort size	-0.00571***	-0.00567	-0.00962	0.0332
	(0.000987)	(0.0121)	(0.00752)	(0.0249)
Constant	0.175***	1.223***	1.280***	1.291***
	(0.0345)	(0.129)	(0.0960)	(0.132)
State effects	Yes	Yes	Yes	Yes
Observations	24,675	8,186	14,312	8,163

Standard errors in parentheses are clustered at the subject level.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
The table reports coefficients from a 2SLS estimation, in which the endogenous regressor "Bologna" is instrumented using the "Share of Bachelor first-year students" (see text). The columns display impact estimates for the following four dependent variables: (1) "graduation within planned instructional time"; (2) "Study duration index"; (3) "Study duration index using imputed data" and (4) "Final grade at graduation".

The results are very similar to the OLS estimates reported in the previous section. The coefficient for the outcome "probability to graduate within planned instructional time" is slightly smaller in size, but still indicates a highly significant 9.83 percentage point increase. For the two study duration outcomes, the coefficients are larger in size, both pointing to a substantial reduction in standardized study duration due to the Bologna reform. The coefficient for the treatment effect on final grades is essentially the same for IV and OLS. All coefficients are statistically significant.

Overall, the findings from both the OLS and the IV estimates point to a clear and consistent picture of the Bologna impacts: On the one hand, the probability to graduate within the planned instructional time as well as the standardized study duration were significantly improved. On the other hand, the overall final grades at graduation are significantly higher, i.e. worse, for the treatment group.

5.3 Subsample results and robustness

In this section, we stratify our sample in several dimensions, and investigate whether specific subgroup results might differ from the findings identified in the previous sections. Specifically, first, we investigate whether treatment effects are different for younger vs. older students (sample cut at the median intake age). Second, we stratify by gender. Third, we include "switchers", i.e. students who started in the specific subject of study at a different university, then switch to and continue at HU (these were not included in our main estimation sample for reasons explicated in section 4). Fourth, we condition on the subsample of students with complete information on their university entrance certificate grade. Fifth, we condition on "local" students (i.e. students originally from Berlin and the surrounding federal state, Brandenburg). These students constitute the largest group in our sample and, given a universal pattern of the time-persistent and inherent inertia of choosing to study at a university where one lives and has grown up, are more likely subject to the exogeneity of the treatment introduction. Sixth and finally, we exclude students from the sample who were affected by the reduction in mandatory years of secondary education qualifying for university from 9 to 8.

We report 2SLS estimates for the following outcomes: probability to graduate within planned instructional time (Table 8, first row), study duration index (Table 8, third row), study duration index using imputed data (Table 8, fifth row), and overall final grade (Table 8, seventh row). The results do not indicate pronounced patterns by age group or gender. Younger students seem to benefit slightly more in terms of the treatment effect on graduation probability within planned time. This is also the case for female students relative to males, and also with respect to better final grades. The differences, however, are not very large, and all impacts remain highly significant also for males. Including the "switchers" in the sample, and focusing on the groups with entrance grade data or local origin, overall produces very similar results, thus underscoring the robustness of the empirical findings. In particular the results for the local group are all highly significant and similar to the overall estimates – all three coefficients are somewhat smaller in size, though, thus possibly representing the actual lower bound on the Bologna reform treatment effects estimated in this paper.

Table 8: IV impact estimates for all outcome variables and stratified samples

	(1) Age below	(2) Age above	(3) Female	(4) Male	(5) Switcher	(6) Entrance grade	(7) Local	(8) G8 excluded
In-time graduation	0.137***	0.0556***	0.118***	0.0786***	0.0945***	0.103**	0.0942***	0.0927***
	(0.0244)	(0.0123)	(0.0199)	(0.0180)	(0.0171)	(0.0421)	(0.0190)	(0.0171)
Observations	12,562	12,113	11,914	12,761	29,649	4,446	14,710	21,515
Duration index	-0.301***	-0.296***	-0.290***	-0.325***	-0.231***	-0.313***	-0.293***	-0.303***
	(0.0532)	(0.0688)	(0.0555)	(0.0790)	(0.0702)	(0.0437)	(0.0748)	(0.0654)
Observations	4,194	3,992	4,227	3,959	10,852	1,196	5,128	7,146
Duration index imputed	-0.294***	-0.343***	-0.308***	-0.341***	-0.499***	-0.179***	-0.313***	-0.320***
	(0.0298)	(0.0339)	(0.0323)	(0.0298)	(0.0361)	(0.0371)	(0.0314)	(0.0283)
Observations	7,390	6,922	7,159	7,153	14,312	3,160	8,666	12,489
Final grade	0.257***	0.221***	0.238***	0.224**	0.282***	0.276***	0.227**	0.234***
	(0.0934)	(0.0767)	(0.0852)	(0.0983)	(0.106)	(0.0978)	(0.0951)	(0.0897)
Observations	4,179	3,984	4,212	3,951	10,806	1,196	5,114	7,127

Standard errors in parentheses are clustered at the subject level.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
The table reports coefficients from a 2SLS estimation, in which the endogenous regressor "Bologna" is instrumented using the "Share of Bachelor first-year students" (see text).The columns display impact estimates for the following stratified samples: (1) Students being younger than the median student when enrolling in the program; (2) Students being older than the median student when enrolling in the program; (3) Female students; (4) Male students; (5) Those students are included who enrolled at a more advanced semester switching from another university; (6) Sample of students for which university entrance grades are available (only from 2005 onwards);(7) Students coming from the federal states of Berlin or Brandenburg; (8) Excluding students affected by the reduction of mandatory secondary education qualifying for university from 9 to 8 years.

5.4 Mechanisms

There are several channels through which we expect the Bologna reform to work, and through which it may have caused the impacts estimated in this paper. First, the standard conjecture regarding Bologna is that the increased structurization implied by the reform incentivizes students to follow their studies along a predetermined class schedule - sometimes by giving them a much smaller amount of liberty in choosing topics and classes than before (Suchanek et al. [2012]). This could then potentially explain both the increase in the probability to graduate within planned instructional time and the decrease in standardized duration (as some kind of compliance effect). Although such a mechanism seems plausible, and may in fact play some role also in our case, there are no data to prove the relevance of this channel conclusively.

A second mechanism related to the idea of a compliance effect is that the new degree structure might generate a stronger connection between student and subject of study. A potential reason for such an increased cohesiveness could be the shorter duration of the program, which reduces the psychological costs associated with graduation. When being able to obtain a degree certificate after three years of higher education (instead of four to five years) students might have a stronger incentive to graduate. Moreover, Bachelor students are able to reconsider their academic interests by switching university for their Master's education, but do not have to drop out of a comprehensive Diploma program to do so.

We can test the hypothesis of increased cohesiveness by estimating the probability of non-retention for treatment and control groups for each semester since enrollment separately. "Non-retention" here means to choose to not remain in the specific field of study in a given semester; it is not exactly a drop-out rate, since we cannot observe whether students actually stop studying or move, for instance, to a different university. Figure A.3 and Figure A.4 in the appendix estimate the probability of non-retention during the first and the sixth semester, following the approach used in section 4. Whereas the same graphs for semesters 2 through 5 (omitted from the appendix, but available on request) show a completely flat profile, the graphs for semesters 1 and 6 do indicate that non-retention rates decrease for the treatment group. This would indicate a twofold mechanism: On the one hand, the Bachelor degree program might make it more likely that students hang on to their subject choice during the first semester (starting effect); and on the other hand it might make it more likely that they

hang on to their subject choice when they are close to finishing and attaining the Bachelor certification (graduation effect). This would be an indicator of a potential "sheepskin effect" induced by the reform. Whereas we want to emphasize the conjectural nature of this conclusion, Figures A.3 and A.4 do provide tentative support.

Third, Bachelor students might face an increased performance pressure induced by a higher number of examinations and by the fact that all course grades contribute to the final grade at graduation, respectively. On the one hand, this might have a positive impact on students' learning efforts eventually decreasing their non-retention risk (see above). On the other hand it can explain the quantitatively worse final grades for Bachelor students. Whereas the final overall grade in the Bachelor degree is composed of all exam grades during the entire program, the final overall grade in the Diploma degree leaves out the grades of the first study phase (pre-Diploma) and has a somewhat stronger emphasis on courses of choice in the second phase. That is, grades from the obligatory classes in the early phase are not counted in the final grade, while grades from chosen classes during the more advanced stages are.

Figure A.5 illustrates the potential quantitative impact of this mechanism on differences in final overall grades by comparing distributions of pre-Diploma and final Diploma grades for a subsample of 1,761 graduates: the large observed difference between pre-Diploma grades and the final grade at graduation of 0.5 grade points on average exemplifies the hypothesis that introductory courses impose an upward pressure on students' final grades. Thus, the comparatively worse performance of Bachelor graduates found in our estimations has to be put in perspective, and instead of implying a negative treatment effect on competencies may represent a spurious impact reflecting changes in the way final grades are composed. Whereas this is spurious in terms of graduates' skills, it is of course real in terms of the final grade written on the Bachelor certificate.

Fourth, the new two-tier system introduces additional uncertainty in a student's academic career because having been successfully admitted to a Bachelor program has no direct implications for potential admittance to a Master's program. That is, the reform generates performance incentives for students during the first stage, as a competitive preparatory step for their subsequent educational or labor market career. This would explain the estimated

reform impacts on the higher probability to graduate within planned time and the lower study duration.

6 Conclusions

The Bologna reform did affect university students' educational outcomes: comparing treatment (Bachelor) and control groups (Diploma), we find that the probability to graduate within planned instructional time increases significantly and sizably, and that the study duration (measured using a standardized index) decreases significantly. At the same time, the average final overall grade is significantly higher (i.e. worse) for the treatment group. Results for the former two outcomes clearly imply a qualitatively positive impact of the reform on students' outcomes: students are more likely to dedicate an amount of educational lifetime to their studies that is closer to planned instructional time; and they are more likely to graduate in time. These results are in line with the reform objectives.

The impacts we find are robust across identification strategies, and subgroup analyses. In particular, there is little difference between female and male students, and between younger and older students, although impact estimates are slightly more positive (qualitatively) for women and for the younger first-year students. Also results for the "local" subsample - which is arguably more strongly affected by the exogeneity of the treatment introduction due to students' home bias - reinforce the overall findings.

Regarding the precise channels through which the reform works, one conjecture discussed in the policy debate is the stronger regimentation of the degree programs post-Bologna. This may be likely to play a role also in our case, but there are no data available to prove this conclusively. We do observe, however, significant decreases in the probability of non-retention (i.e. of not remaining in the program) for the treatment group during the first and sixth semester, respectively. This may point to a mechanism of the Bachelor program being more likely to retain students at the very beginning (starting effect) and close to finishing their studies (graduation effect), and could explain the positive reform impacts. Consequently, there is some indication that the possibility to obtain a labor market signal certifying a specific amount of human capital by obtaining a less costly university degree might actually incen-

tivize a larger share of students to graduate. Moreover, the competitive forces induced by the fact that students have to reapply for a Master's program might incentivize them to not take too much time for graduating from the Bachelor program.

Although we find Bachelor graduates' final overall grades to be significantly worse than those of Diploma graduates, this does not necessarily imply a qualitative decrease of student performance: it is in part explained by the fact that the final grade in the Bachelor degree is composed of all exam grades during the program, while the final grade in the Diploma programs leaves out the grades of the first study phase (pre-Diploma) and has a somewhat stronger emphasis on chosen courses in the second phase.

In sum, we conclude that the Bologna reform has (qualitatively) positive impacts on important individual-level educational outcomes that are relevant for students' future labor market career. Moreover, the micro level impacts on reduced study duration and increased within-time graduation rates directly translate into desirable outcomes from a societal perspective, at the very least for the systems of social security and higher education. The extent to which our results extrapolate to other universities is determined by the federal structure of the higher education system as well as university's autonomy during the implementation process. However, the treatment we are analyzing implied similar consequences for all German universities, namely the reduction in study durations. Moreover, the framework conditions under which HU implemented the Bologna Reform were not specific to universities in Berlin, but are representative of many other universities all over Germany. Whereas the precise size of the positive effects of the Bologna Reform might partly depend on the HU-specific regulatory set-up, their robustness along with our analysis of the driving forces suggest that the underlying mechanisms are transferable to other institutions.

References

Agasisti, Tommaso and Thomas Bolli (2013). "The impact of the Bologna reform on the productivity of Swiss universities". In: *Higher Education Quarterly* 67.4, pp. 374–397.

Araque, Francisco, Concepción Roldán, and Alberto Salguero (2009). "Factors influencing university drop out rates". In: *Computers & Education* 53.3, pp. 563–574.

Arulampalam, Wiji, Robin A Naylor, and Jeremy P Smith (2004). "A hazard model of the probability of medical school drop-out in the UK". In: *Journal of the Royal Statistical Society: Series A (Statistics in Society)* 167.1, pp. 157–178.

Bean, John P (1980). "Dropouts and turnover: The synthesis and test of a causal model of student attrition". In: *Research in higher education* 12.2, pp. 155–187.

Boero, Gianna, Tiziana Laurenti, and Robin Naylor (2005). "An econometric analysis of student withdrawal and progression in post-reform Italian universities". In: *CRENoS Working Paper 2005/4*.

Bologna Declaration (1999). "The Bologna Declaration of 19 June 1999". In: *Joint declaration of the European Ministers of Education*.

Bratti, Massimiliano, Stefano Staffolani, and Chiara Broccolini (2006). "Is'3+ 2'equal to 4? university reform and student academic performance in italy". In: *Universita politecnica delle Marche*.

Cappellari, Lorenzo and Claudio Lucifora (2009). "The "Bologna Process" and college enrollment decisions". In: *Labour Economics* 16, 638–647.

Cardoso, Ana Rute, Miguel Portela, Carla Sá, and Fernando Alexandre (2008). "Demand for higher education programs: the impact of the Bologna process". In: *CESifo Economic Studies* 54.2, pp. 229–247.

Crosier, David and Teodora Parveva (2013). "The Bologna Process: Its impact in Europe and beyond". In: *Fundamentals of Educational Planning 97*.

D'Hombres, B. (2007). "The impact of university reforms on dropout rates and students? status: Evidence from Italy". In: *Mimeo, CRELL - Centre for Research on Lifelong Learning*.

De Rudder, Helmut (2010). "Mission Accomplished? Which Mission? The". In: *Higher Education Review* 43.1, pp. 3–20.

Destatis (1995). "Effizienzbemessung der Hochschulausbildung auf statistischer Grundlage". In: *Band 7 der Schriftenreihe Spektrum Bundesstatistik*.

— (2003). "Nichtmonetäre hochschulstatistische Kennzahlen 1980 - 2002". In: *Fachserie 11 Reihe 4.3.1*.

Gaudecker, Hans-Martin von (2014). "Templates for Reproducible Research Projects in Economics". `https://github.com/hmgaudecker/econ-project-templates`.

Heinze, Torben and Christoph Knill (2008). "Analysing the differential impact of the Bologna Process: Theoretical considerations on national conditions for international policy convergence". In: *Higher education* 56.4, pp. 493–510.

Horstschräer, Julia and Maresa Sprietsma (2015). "The effects of the introduction of Bachelor degrees on college enrollment and dropout rates". In: *Education Economics* 23, 296–317.

Mechtenberg, Lydia and Roland Strausz (2008). "The Bologna Process: How student mobility affects multi-cultural skills and educational quality". In: *International Tax and Public Finance* 15.2, pp. 109–130.

OECD (2011). *Education at at Glance 2011: OECD Indicators.*

Pietro, Giorgio Di and Andrea Cutillo (2008). "Degree flexibility and university drop-out: The Italian experience". In: *Economics of Education Review* 27, 546–555.

Studentenwerk (1997-2012). "Die wirtschaftliche und soziale Lage der Studierenden in Berlin". In: *Regionalauswertung der Sozialerhebung des Deutschen Studentenwerks.*

Suchanek, Justine, Manuel Pietzonka, Rainer Künzel, and Torsten Futterer (2012). "Bologna (aus) gewertet". In: *Eine empirische Analyse der Studienstrukturreform. V&R unipress, Göttingen.*

Voegtle, Eva M, Christoph Knill, and Michael Dobbins (2011). "To what extent does transnational communication drive cross-national policy convergence? The impact of the bologna-process on domestic higher education policies". In: *Higher education* 61.1, pp. 77–94.

A Appendix

Figure A.1: Distribution of university entrance certification grades for Diploma and Bachelor students

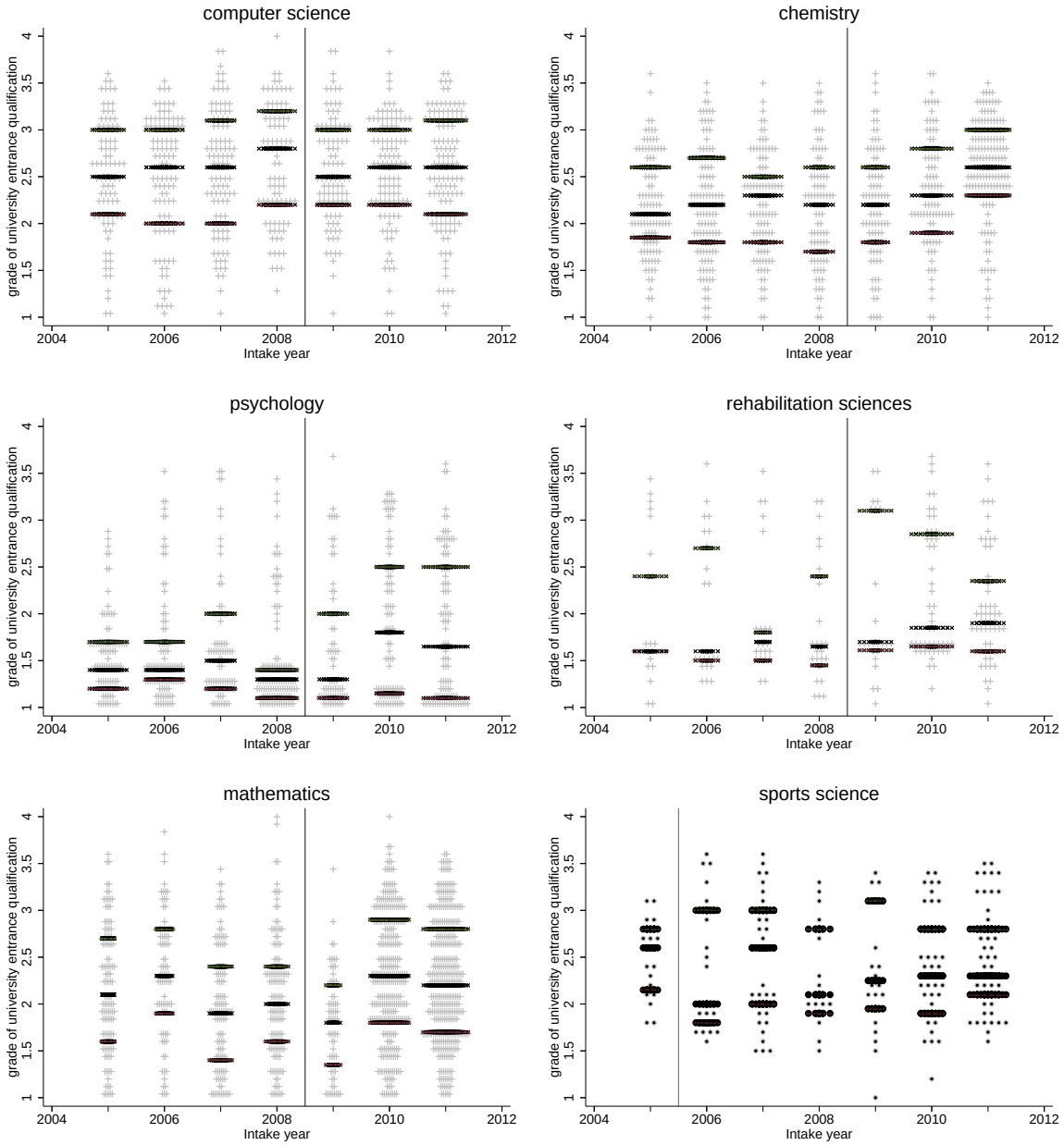


Figure A.2: Distribution of university entrance certification grades for Diploma and Bachelor students in geography

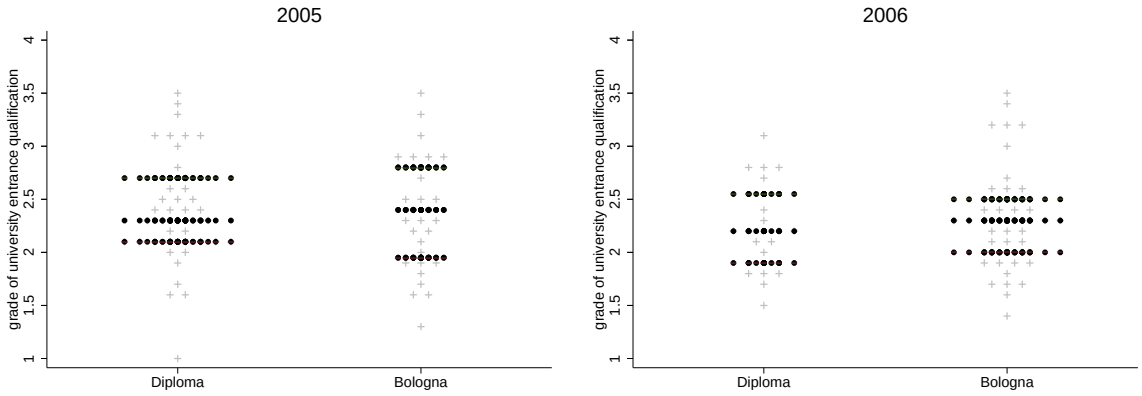


Figure A.3: Outcome dynamics around treatment introduction: Student non-retention during the first semester

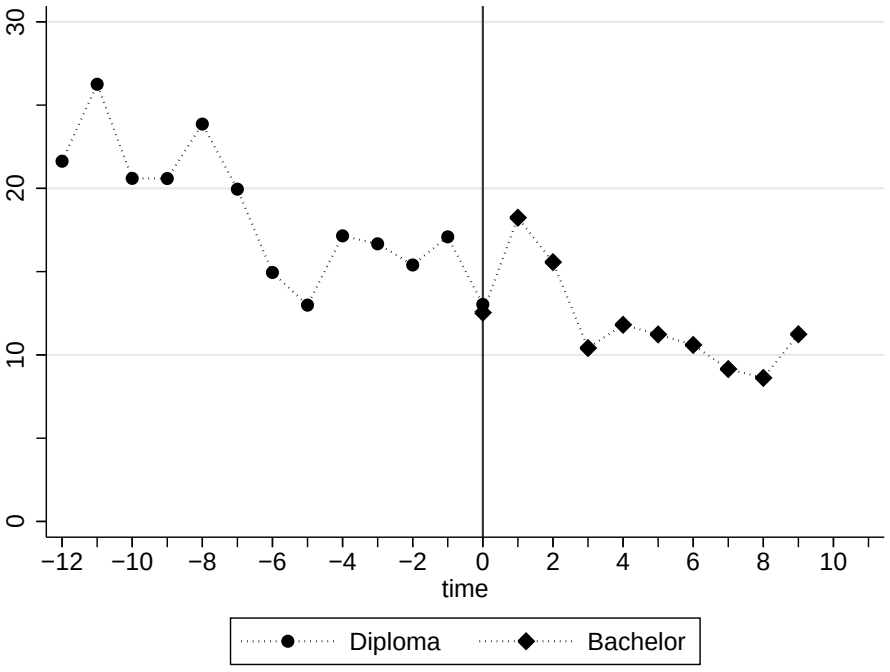


Figure A.4: Outcome dynamics around treatment introduction: Student non-retention during the sixth semester

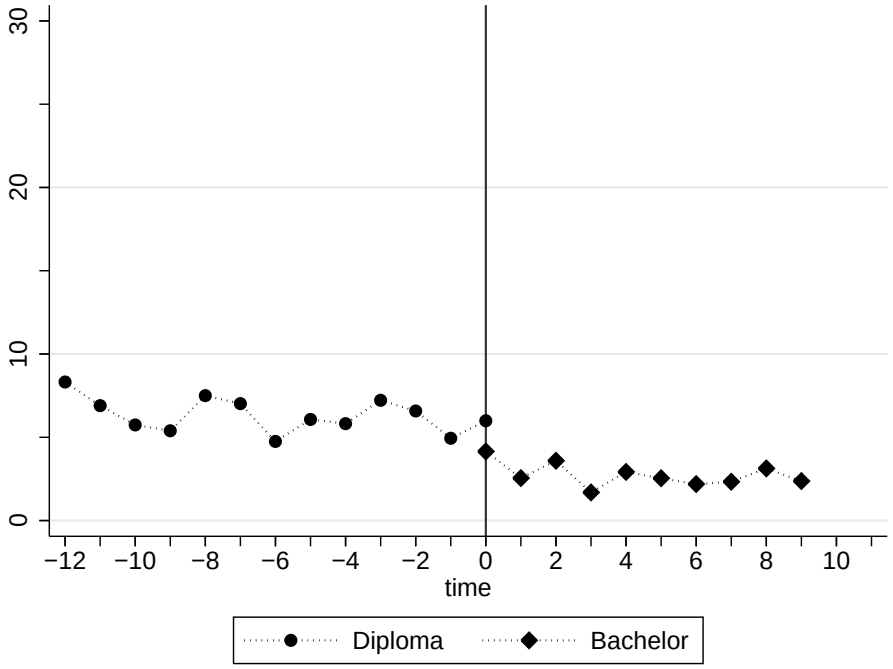
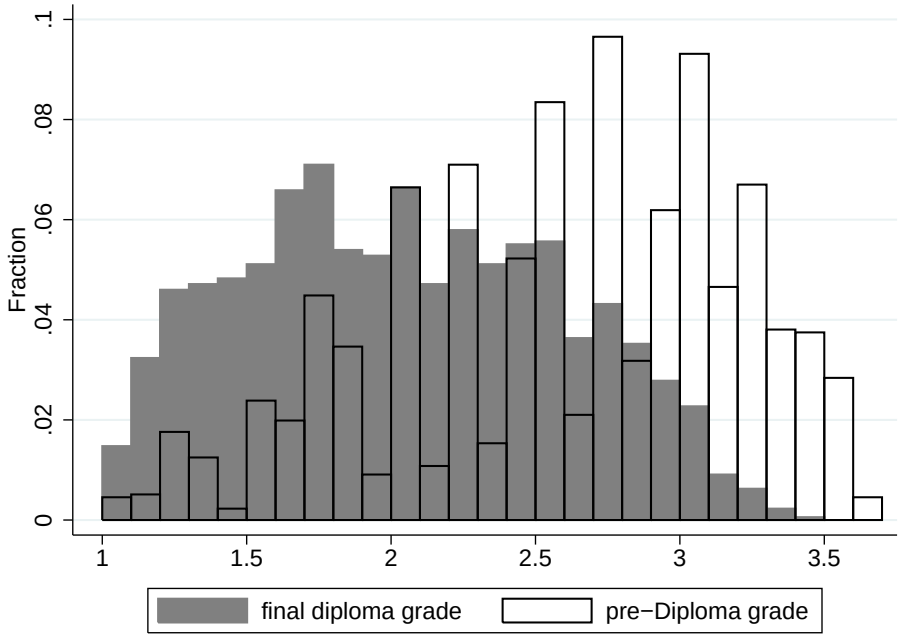


Figure A.5: Distribution of pre-Diploma and final Diploma grades



Subsample of N=1,761 Diploma graduates for whom data on pre-Diploma grades are available.