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The effect of tuition fees on university graduation

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Abstract

This paper examines the impact of tuition fees on graduation rates among high-school leavers. We analyse the introduction of fees in several German states in 2006-07 (around EUR 1,000 annually), using administrative microdata on all university graduates and a difference-in-differences approach. The share of high-school leavers graduating fell by 1.8 percentage points, which is less than the 3.2-percentage point drop in enrolment, indicating many deterred students would not have graduated without fees. This underscores the importance of studying not only enrolment but also graduation rates, particularly in systems with high dropout rates and "ghost students"–students enrolling primarily for non-educational benefits.

JEL-codes: I22, I23, I28
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1 Introduction

Higher education plays an important role in innovation and growth (Barro, 2001; Hanushek and Woessmann, 2008), thereby generating substantial societal welfare. It is also beneficial from an individual point of view in terms of higher earnings and and better health (see., e.g. Oreopoulos and Petronijevic, 2013; Barrow and Malamud, 2015; Kamhöfer, Schmitz, and Westphal, 2019). Given that there are both social and individual benefits, it is not clear who should pay for higher education. The question of whether and to what extent students should contribute privately to the cost of their education has been a focal point in the long-standing debate on higher education financing (see, e.g., Janeba, Kemnitz, and Ehrhart, 2007; Murphy, Scott-Clayton, and Wyness, 2019).

This issue has sparked intense discussions and contrasting policy approaches. For instance, the United Kingdom introduced tuition fees in 1998 and has since raised them considerably (Murphy, Scott-Clayton, and Wyness, 2019; Azmat and Simion, 2021), whereas Ireland abolished fees in 1996 (Denny, 2014) and Ecuador in 2008 (Molina and Rivadeneyra, 2021). Meanwhile, the United States, despite having some of the highest tuition fees globally, offers at least 16 statewide and over 200 local "free college" programmes (Monaghan, 2024). An important empirical question in this context is how large a proportion of students would be deterred from obtaining a university degree by the introduction of fees.

In this paper, therefore, we analyse how the introduction of tuition fees affects university graduation of high-school leavers. We take advantage of the introduction of tuition fees of around EUR 1,000 per year in seven of Germany's sixteen federal states in 2006 and 2007, following a ruling by the Federal Constitutional Court that overturned a federal ban on tuition fees. For our empirical analyses, we combine individual-level administrative data on all university graduates in Germany with county-level administrative data on high-school leavers who obtained university entrance qualifications between 2000 and 2007/08. We apply a difference-in-differences approach, comparing the development of graduation rates in states that introduced tuition fees with those in states that did not.

Our study shows that tuition fees negatively affect the share of high-school leavers who graduate from university (graduation effect), but this impact is less pronounced than the effect on the share of high-school leavers who enter university (enrolment effect). Specifically, we observe that tuition fees reduce the university graduation rate among eligible school leavers by 1.8 percentage point (pp), while the corresponding decrease in the enrolment rate is 3.2 pp. The differences between the enrolment and graduation effects suggests that a substantial fraction of students deterred by tuition fees would not have graduated even in the absence of fees. While our main specification examines university graduation within eight years of enrolment, our results remain nearly identical when using six- or ten-year windows. Additionally, we demonstrate that the enrolment and graduation effects are robust across various specifications and estimators, including different estimators for difference-in-differences with staggered treatment timing. Event study analyses and placebo checks further support the validity of the common trend assumption.

We also find that tuition fees affect women more than men, both in terms of graduation and enrolment. One explanation for this finding is the lower representation of women in science, technology, engineering and mathematics (STEM) study programms, which tend to offer higher salaries for their graduates and where no negative effect of tuition fees on graduation is observed. Additionally, the negative impact of tuition fees is more pronounced in economically disadvantaged counties, suggesting that tuition fees might increase existing socio-economic inequalities. Finally, we present evidence suggesting that our estimates represent a lower bound compared to a scenario in which all states impose tuition fees.

Our study makes three contributions to the literature. First, we contribute by focussing on graduation rates, whereas most previous research examines enrolment decisions when analysing changes in the cost of higher education (see, for example, Dynarski, 2003; Kane, 2003; Cornwell, Mustard, and Sridhar, 2006; Deming and Dynarski, 2010; Kelchtermans and Verboven, 2010; Nielsen, Sørensen, and Taber, 2010; Dearden, Fitzsimons, and Wyness,

2014; Barr, 2015; Azmat and Simion, 2021).[1] However, graduation is a more critical outcome than enrolment alone, both from the perspectives of human capital theory (Becker, 1964) and signalling theory (Stiglitz, 1975). This distinction is particularly important in systems with high dropout rates, such as Germany and many other countries (OECD, 2008), where enrolment and graduation are clearly distinct measures.

Second, we contribute to a better understanding of the effects of private costs of higher education at the no-fee-to-fee margin, the zero price margin. This margin is particularly relevant as about one third of OECD countries do not charge tuition fees (OECD, 2021) but frequently discuss their introduction, while in many fee-charging countries, initiatives to abolish tuition fees are gathering support (Monaghan, 2024). The impact of introducing tuition fees may differ from changes in existing fees or adjustments in financial support at institutions where tuition fees are already in place (see, for example, Shampanier, Mazar, and Ariely, 2007). Price increases may have stronger effects due to loss aversion (Malloy, 2015), and the introduction of fees may also have a pronounced impact because of their salience (e.g. Bettinger et al., 2012; Barr and Turner, 2018; Dynarski et al., 2018). Additionally, tuition fees can have a particularly large effect at this margin due to loan aversion. For example, in Germany, few students take out loans (Thomsen and von Haaren-Giebel, 2016), meaning that fees must be covered from monthly budgets. Furthermore, the introduction of tuition fees adds complexity and uncertainty for prospective students. This alone may discourage potential students, even if they would later be exempt from the fees (Dynarski et al., 2021; Burland et al., 2023).

Third, our study contributes to the literature on measures against "ghost students", i.e. students who enrol in higher education not with the intention of earning a degree but to access non-educational benefits (Hall, 2023), including subsidized public transport and subsidized health insurance. These ghost students pose several problems: They exploit

[1]Notable exceptions include Castleman and Long (2016); Deming and Walters (2017); Denning, Marx, and Turner (2019), among others, which examine different contexts and primarily assess the effects of changes in financial aid on existing fees in high-fee environments.

enrolment benefits, generating public costs through subsidised health care, public transport, and other services—estimated at EUR 2,750 per student annually in Germany, or 3.3% of higher education spending (Berens, Henao, and Schneider, 2024). They create inefficiencies in campus management by occupying slots meant for genuine students, straining administrative and IT departments. Further, some ghost students might exploit their enrolment status to fraudulently obtain financial aid. Another growing concern is that access to university-hosted email addresses and virtual private networks (VPNs) can facilitate cybercriminal activities (Hall, 2023; Viano, 2024): Official email addresses, such as .edu domains, can bypass spam filters more easily, enabling scammers to create multiple accounts for phishing schemes or other cybercrimes. Many countries grapple with the issue of ghost students and debate measures to address them, including diverse cases such as the U.S. (Hall, 2023; Viano, 2024), Australia (Linden, Van Der Ploeg, and Hicks, 2021), Germany (Berens, Henao, and Schneider, 2024), Slovenia (Henriksen, Dillon, and Ryder, 2015), and Colombia (Fergusson et al., 2023).

Tuition fees might be an effective measure to discourage ghost students: If the cost of university education rises and exceeds the monetary value of these non-educational benefits, rational ghost students will stop enrolling. The issue of ghost students is particularly prominent at the no-fee-to-fee margin, as without tuition fees, students face virtually no costs of enrolment yet might still benefit from the non-educational advantages associated with enrolment. While previous studies have studied the effect of tuition fees on university *enrolment* among high-school leavers in Germany (Hübner, 2012; Bruckmeier and Wigger, 2014; Bietenbeck et al., 2023), we are the first to examine their effect on university *graduation* among high-school leavers in this context. Comparing our graduation results with prior studies and our enrolment findings suggests that tuition fees are less detrimental than previously thought, supporting the idea that they deter ghost students. However, while effective in this regard, tuition fees also have adverse effects by discouraging high-school leavers from earning university degrees.

The paper is structured as follows: Section 2 outlines the German higher education system and the introduction of tuition fees. Section 3 describes the data used in the analysis, followed by Section 4, which details the difference-in-differences approach employed. Section 5 presents the empirical findings, and Section 6 concludes with a discussion of the results and their implications.

2 Institutional setting

2.1 The German higher education system

In Germany, university education and its access is mainly organized and financed by the 16 federal states. The large majority of universities is public, with private universities making up only around one percent of degrees in Germany when tuition fees were introduced (Federal Statistical Office, 2008). In all states, the typical route to university education is to obtain the general university entrance qualification (*Allgemeine Hochschulreife, Abitur*) at a general education school, typically the *Gymnasium* (high school).[2] There is no general admission test at universities and if demand exceeds the supply of study places in a subject at a university, students are usually selected according to the final grades of their school-leaving certificate. The school-leaving certificates are awarded at the beginning of the summer and enable enrolment in the winter term (start in October) of the same year. For this reason, most universities mostly offer enrolment in a study programme in the winter term and only in a few cases in both the winter and the summer term (start in April).

[2] A smaller proportion of pupils obtain a subject-specific university entrance qualification (*fachgebundene Hochschulreife*), which grants access only to universities within the respective subject area, or a technical college entrance qualification (*Fachhochschulreife*), which comprises both a school-based and a vocational component and allows enrolment at a technical college (*Fachhochschule*).

2.2 Tuition fees

Despite higher education being organised at the state level, general tuition fees were banned under a *federal* law enacted in the 1970s. This prohibition was later challenged by several federal states, and in 2005, the Federal Constitutional Court ruled in favour of the states. This ruling led to the abolition of the ban, which two federal states—North Rhine-Westphalia and Lower Saxony—used in 2006, followed by five more in 2007, to introduce tuition fees. Figure 1 details the timeline for when tuition fees were introduced for new students and when the corresponding legislation was passed (see Appendix Table A.1 for further details and Figure A.1 for a map highlighting the German states that introduced tuition fees). Notably, tuition fees did not apply exclusively to newly enrolled students; students already enrolled were also required to pay tuition fees starting in 2007.

The tuition fees were generally set at EUR 500 per semester (EUR 1,000 per year) in five federal states. In the two other states, Bavaria and North Rhine-Westphalia, universities were permitted to set their own tuition fees up to this maximum amount. While almost all universities in these two states charged the maximum, a significant share of technical colleges—ranging from one-third to one-half—either waived the fees or charged lower amounts during the initial semesters after their introduction (see Hübner, 2012).

Several measures were implemented to mitigate the potential negative effects of tuition fees. First, most states exempted specific groups of students, such as those with children or disabilities, from paying fees. Second, some federal states introduced simplified and subsidized loan schemes to ease the financial burden on students. Third, universities were required to use the revenue from tuition fees to improve study conditions, such as upgrading technical equipment or hiring additional teaching staff (Deutscher Bundestag, 2009). These measures suggest that any negative effects on graduation rates may be less pronounced in this context compared to a regime where tuition fees are introduced without such accompanying measures.

Despite these measures, the introduction of tuition fees sparked widespread nationwide

protests, organised by students and supported by labour unions. Public pressure quickly mounted, leading to the abolition of tuition fees in Hesse in 2008 and Saarland in 2010, shortly after their implementation. The remaining states followed suit between 2011 and 2014 (see Figure 1). As with their introduction, the abolition of tuition fees affected both newly enrolled students and those already attending university.

Tuition fees in Germany have been the focus of several prior studies. For example, Dwenger, Storck, and Wrohlich (2012) and Mitze, Burgard, and Alecke (2015) demonstrate that tuition fees influence the mobility of university applicants, with some students opting to study in non-fee states to avoid fees. Hübner (2012), Bruckmeier and Wigger (2014), and Bietenbeck et al. (2023) find that tuition fees reduce university enrolment,[3] while Bahrs and Siedler (2019) show that tuition fees lower the intention to enrol, with the effect primarily driven by students from lower-income households. In contrast to these studies focusing on prospective students, Bietenbeck et al. (2023) find that tuition fees increased degree completion rates and study effort among students who were already enrolled at the time of their introduction. Furthermore, Bietenbeck et al. (2023) demonstrate that the abolition of tuition fees led to a 2.3 pp decrease in the completion of Bachelor's degrees within three years. Similarly, Berens, Henao, and Schneider (2024) find that the removal of fees resulted in students completing fewer courses per semester and taking longer to finish their degrees.

In addition to general tuition fees, there are two other types of fees for university students. First, several states have implemented targeted tuition fees for so-called "long-term students"—those enrolled well beyond the nominal duration of their degree programme. These fees usually amounted to EUR 500 per semester. Appendix Table A.1 provides an overview of the implementation dates for these long-term fees and the specific regulations governing their application. Notably, all treated states and several control states had implemented these targeted fees prior to the introduction of general tuition fees. In states that adopted general tuition fees, these replaced the long-term fees. As the payment amounts

[3]While the effect is persistently statistically significant in Hübner (2012) and Bietenbeck et al. (2023), it loses significance in Bruckmeier and Wigger (2014) when additional controls are included.

for general and long-term fees were typically the same, the introduction of general tuition fees had little impact on long-term students. This observation will be utilised for placebo checks. Second, administrative fees are charged once per semester across all federal states, primarily covering administrative costs. The exact amount varies between universities, averaging around EUR 150 per semester during our observation period (Bruckmeier, Fischer, and Wigger, 2013).

Enrolling at a university provides several benefits beyond access to higher education (see Berens, Henao, and Schneider (2024) for a detailed description of these benefits). These include reduced or free health insurance contributions, lower costs for local public transport, and discounted admission to cultural institutions such as museums, public swimming pools, concerts, and cinemas. Additional advantages include continued eligibility for child allowance and, for international students, the opportunity to obtain a residence permit with a work permit for up to 120 days per year. Further, students have access to an official university address and a VPN connection. Students in Germany can also apply for the means-tested public financial aid programme (BAföG), which offers support as a 50/50 combination of non-refundable grants and refundable loans. These benefits can make university enrolment cost-effective even for those not pursuing a degree, such as individuals seeking employment after finishing school. Such individuals, often referred to as "ghost students," enrol primarily to take advantage of the associated benefits. However, the introduction of tuition fees represents a significant price increase for university enrolment. For ghost students, this price increase may outweigh the benefits, discouraging enrolment.

2.3 Further relevant policy changes

Three other relevant policy changes took place during our observation period. Below, we outline these changes and discuss their relevance to our empirical analyses.

G8 and G9. During our observation period, two German states altered the length of secondary schooling as part of the G8 and G9 reforms (Huebener and Marcus, 2017), which

previous studies found to impact higher education decisions (Marcus and Zambre, 2019). Saxony-Anhalt and Mecklenburg-West Pomerania transitioned from a 12-year to a 13-year system in 2001 before reverting to 12 years in 2007 and 2008, respectively.[4]

Bologna reform. Until the mid-2000s, universities primarily awarded single-tier degrees such as the Diploma, Magister, and State Examination, which had a nominal duration of about five years, though students often took longer to complete them (see Figure A.2). From the mid-2000s to the mid-2010s, as part of the Bologna reform aimed at harmonising the European higher education system, universities transitioned to a two-tier structure. This system introduced Bachelor's degrees with a nominal duration of three (sometimes four) years, followed by optional Master's degrees lasting two (and occasionally one) years.

While the G8 and Bologna reforms were not directly linked to the introduction or abolition of tuition fees, it is possible that fee- and non-fee states coincidentally differed in the timing of these policy changes. To address this, we will carefully account for these potential overlaps in robustness tests by including control variables for these reforms or excluding states that were particularly affected.

Military service. Compulsory military service was abolished across Germany in 2011. Before its abolition, men were required to serve nine months in the army or ten months in civilian service.[5] University-bound men typically completed this service between finishing high school and starting university, causing many to delay their enrolment by a year. In contrast, most women intending to pursue higher education enrolled immediately after leaving school. We take this into account in our empirical analysis and present results separately for women and men, as compulsory military service and its abolition affected only men. Since the abolition likely had a similar impact on men in both tuition fee and non-tuition fee states, it is unlikely to confound our findings.

[4]The shift to 13 years resulted in no high-school leavers in 2001, while the return to 12 years produced two cohorts graduating in the same year.

[5]In the years leading up to the abolition, the proportion of men exempted from service increased considerably.

3 Data

Our main dataset is the individual-level data from the German Final Examination Register (RDC 2023a), which covers the entire population of students who graduated from an institution of higher education in Germany between 1995 and 2020. For this purpose, all institutions collect data on all final examinations taken and forward them once a semester to the statistical offices of the federal states, before they are finally pooled at the federal level. It contains individual-level information on the type of examination (such as university, subject, and degree), the student's academic career (such as year of enrolment, length of study, and previous academic examinations) as well as demographic characteristics (gender, nationality, county, and year of school-leaving certificate). Additionally, we use data from the German Student Register (RDC 2023b), which provides similar information to the Final Examination Register but covers all enrolled students, not just graduates.[6]

We supplement the German Final Examination and Student Register with aggregated data from several other sources. These include county-level data from the statistical offices on the number of high-school leavers, i.e., the number of school leavers with a general university entrance qualification from a general education school (Federal Statistical Offices 2023), which we use to construct our outcome variable. Finally, we use data on economic variables at the county level published by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR 2023) to include them as control variables in our regressions as well as a regional socio-economic status ranking (IW Consult 2007) for our heterogeneity analysis. We merge the additional information at the county-cohort level.

3.1 Outcome variable

Our main outcome variable is the graduation rate, which relates to the share of a high-school-leaving cohort that obtained a university degree. While information on university degrees

[6]Although it is not necessary for our main analysis, it is important to note that the Student Register cannot be linked at the individual level to the Final Examination Register due to data confidentiality issues.

is available at the individual level in the Final Examination Register, there is no register with individual-level information on school leavers in Germany. However, aggregated data on the number of high-school leavers is available from Federal Statistical Offices (2023).[7] We therefore aggregate the individual-level data on university degrees to the lowest geographical level available in the aggregated data on high-school leavers, which is the county level.

Our main outcome variable $G_{d,c}$, the share of high-school leavers who obtained a university degree, is constructed as follows:

$$G_{d,c} = \frac{\sum_{i \in d,c} \text{UniGraduate}_i}{N_{d,c}^{\text{HS-Leaver}}}, \tag{1}$$

where $N_{d,c}^{\text{HS-Leaver}}$ denotes the number of high-school leavers from school-leaving cohort c in county d and $UniGraduate_i$ is a binary variable indicating whether individual i from cohort c and county d graduated from university.

While it is theoretically possible to obtain a university degree 30 or 50 years after leaving high school, we focus on obtaining a *first* degree at a public university within *eight* years after enrolment. This constraint recognises that many students will need longer than the nominal period of around three to five years, but ensures that students will be affected by tuition fees for much of their time at university. In Section 5.4, we demonstrate that the results remain highly similar when using alternative upper limits within the range of 5 to 10 years after enrolment, rather than the default eight years. In addition, we only consider students who enrol no later than one year after leaving school to avoid enrolment when tuition fees had already been abolished or were announced to be abolished. While some studies on tuition fees in Germany only consider school leavers with direct enrolment

[7] We exclusively consider graduates with the requirement for direct admission to university without additional qualifications following the approach of Hübner (2012); Bruckmeier and Wigger (2014); Bietenbeck et al. (2023). More specifically, the aggregated number includes all individuals who left a general education school (*algemeinbildende Schulen*) with a general university entrance qualification (*allgemeine Fachhochschulreife*).

(Hübner, 2012; Bruckmeier and Wigger, 2014), we follow the approach of (Bietenbeck et al., 2023) with enrolment up to one year after school leaving, which takes into account military service, which for many men delays enrolment by one year. Furthermore, to avoid double counting of the same individuals we only consider the first degree taken at universities in Germany.[8] Further, we focus on high-school leavers who attended school in Germany and graduated from a public university—the predominant pathway to higher education in the country.[9] In summary, the numerator of Equation (1) takes into account first degrees at public universities obtained within eight years after enrolment for students who enrolled in the year of leaving school or the year after.

To get a better understanding of our results, we compare the effect of tuition fees on graduation rates with their effect on enrolment rates. For this purpose, we introduce the enrolment rate $E_{d,c}$ as additional outcome variable, where the numerator reflects whether an individual enrols at university, rather than whether they graduate. The denominator and the previously mentioned restrictions remain unchanged. This outcome variable has been utilised in previous studies (Hübner, 2012; Bruckmeier and Wigger, 2014; Bietenbeck et al., 2023).

While we cannot directly observe ghost students, we use the difference between the graduation and enrolment effects as a proxy for the share of ghost students among high-school leavers. In Appendix B, we provide a detailed explanation of the rationale and underlying assumptions behind this measure.

[8]We exclude master degrees, doctoral exams and exams from second degrees. In some degrees it is possible to continue studying and repeating the exam to improve your grade. In this cases we only consider the first exam taken.

[9]Our main analysis excludes private universities, which were not subject to general tuition fees and accounted for only about three percent of university enrolment in Germany during our observation period. Further, Hübner (2012) and Bruckmeier and Wigger (2014) include degrees from technical colleges, whereas we focus exclusively on universities due to exceptions in tuition fee implementation and data limitations, aligning with Bietenbeck et al. (2023). Importantly, we demonstrate that our findings remain robust when applying the restrictions used in these other studies.

3.2 Sample

The short period between the introduction and abolition of tuition fees (see Section 2) requires a careful approach to estimating their causal effect on university graduation. Therefore, we impose several sample restrictions.

First, we exclude the states of Hesse and Saarland from our main sample, because of two reasons. On the one hand, these two states abolished tuition fees shortly after the 2007 introduction (in 2008 and 2010, respectively). This makes their treatment fundamentally different from that of the other five tuition-fee states as even the first tuition fee cohort in these two states is strongly affected by the abolition of tuition fees. On the other hand, because of data issues the number of high-school leavers is not available at the county level but only at the state level for some years during our observation period. However, our conclusions are robust to including these two states (see Section 5.2).

Second, we focus only on the first two tuition fee cohorts in our main specification. These cohorts were affected by tuition fees both in their enrolment decision and during all (or at least most) of their study period.[10] In subsequent analyses, we do not only consider the first two affected cohorts but also the following two treated cohorts and calculate a separate coefficient for each cohort. These further treated cohorts were charged tuition fees at the time of enrolment but had to pay tuition fees for an increasingly smaller proportion of their studies. Our focus on the first two treated cohort results in an unbalanced sample as in our sample two states charged tuition fees starting from 2006 and three states in 2007.

As a final sample restriction, we set the year 2000 as the starting point of our observation period, as the examination register contains a higher share of missing values in earlier years for key variables, such as the county of school-leaving, due to data reporting issues. While the share of missing values is up to 15 per cent for the years 1995 to 1999, it is considerably lower in the following years. We show in robustness checks that altering the starting year of

[10]This means that high-school leavers in our sample are affected by fees for their entire study duration or at least four years in case of direct enrolment and for at least three years in the case of enrolment one year after leaving school.

our observation period has no effect on the significance and magnitude of our results.[11]

In summary, our main sample comprises high-school leavers from 14 of Germany's 16 states. These individuals obtained their university entrance qualification between 2000 and 2008 for the control states and for the states that introduced tuition fees in 2007, and between 2000 and 2007 for the states that introduced tuition fees in 2006. This leaves us with 1,853,320 school leavers from eight to nine school leaving cohorts and 369 counties.[12]

3.3 Descriptive statistics

To enhance understanding of our sample and key variables, we present various descriptive statistics for the 1,853,320 high-school leavers in our sample. Figure A.2 includes two graphs illustrating the timing of enrolment and graduation. Panel A shows that over 57% of high-school leavers enrol at university either immediately (32%) or within one year of leaving school (25%). In contrast, only about 10% enrol two or more years after leaving school. Panel B depicts the proportion of high-school leavers who enrol within one year of leaving school and successfully obtain a university degree, categorised by study duration. The data reveal that only a small fraction graduate in less than four years. The majority complete their studies between four and eight years after enrolment, with a notable decline in graduation rates beyond this period. For this reason, our main analysis focuses on graduation within eight years of enrolment.

Table 1 shows that slightly more than half of high-school leavers (56.3%) are female. 61.1% of school leavers come from fee states, meaning states that introduced tuition fees at some point during our observation period, and about 16.1% of the observations in our sample are actually treated in the sense that tuition fees were charged in their home state when they left school. 674,432 of the 1,853,320 school leavers in our sample graduated from university within eight years, meaning that our outcome variable is 36.4% on average. Among those

[11] See Bietenbeck et al. (2023) for more information on missing data in the Final Examination Register.

[12] County mergers during the observation period were accounted for by aggregating data to the most recent territorial status (2023). Additionally, three counties in Bavaria report the number of high-school leavers collectively. Figure A.1 provides an overview of the locations of the counties included in our sample.

who graduated within this time frame, 20.8% earned degrees in humanities, 32.4% in social sciences, 39.7% in STEM, and 6.8% in other subjects. Additionally, 58.9% of graduates were female, a higher proportion than at the enrolment stage, highlighting that women are more likely to complete university degrees, conditional on enrolment.

4 Empirical strategy

To analyse the impact of tuition fees on university graduation rates, we employ a difference-in-differences (DiD) approach, comparing the trends in graduation rates between states that introduced tuition fees and those that did not.

We estimate versions of the following equation

$$G_{d,c} = \beta \cdot Fee_{d,c} + \rho \cdot TransitionCohort_{d,c} + \gamma_d + \delta_c + \varepsilon_{d,c}. \tag{2}$$

$G_{d,c}$, as defined in Equation (1), represents the proportion of individuals from cohort c in county d who obtained a university degree within eight years of enrolment. The variable $Fee_{d,c}$ is a dummy indicating whether the state in which county d is located levied tuition fees in the year of school leaving. The term γ_d represents a vector of county dummies to account for local differences in graduation rates, δ_c is a vector of dummies for school-leaving cohorts to capture time variations in graduation rates, and $\varepsilon_{d,c}$ is the error term. $TransitionCohort_{d,c}$ is an indicator for the cohort that graduated just before the introduction of tuition fees, reflecting their ambiguous treatment status. Students in this cohort were not subject to tuition fees in their first year if they enrolled immediately after high school, but were required to pay fees in their first year if they delayed enrolment by a year. Controlling for this cohort effectively excludes them from both the treatment and control groups. We also estimate alternative specifications of Equation (2), incorporating additional control variables such as the county's economic conditions, university characteristics, and high-school cohort attributes.

The main parameter of interest, β, shows the effect of tuition fees on university graduation rates. Although the regression uses data at the county-year level, we weight the observations by the number of high-school leavers (i.e., the denominator of our outcome variable) to recover coefficients equivalent to those from an individual-level regression (see Hübner, 2012; Marcus and Zambre, 2019; Bietenbeck et al., 2023). We cluster the standard errors at the state level, i.e. at the level of treatment introduction. We also estimate the equation using $E_{d,c}$ as the outcome variable, to ensure comparability between our results for graduation rates and enrolment rates.

Our main identification assumption is that university graduation rates would have followed the same trend in treatment and control states in the absence of the introduction of fees. While this assumption cannot be tested directly, we provide support for its plausibility by demonstrating that graduation rates in treatment and control states exhibited comparable trends prior to the introduction of tuition fees.

Our estimated effects should be interpreted as intent-to-treat effects for several reasons. First, we assign the treatment indicator based on the year and county (and thus state) of school leaving, whereas university graduation is measured regardless of the state where the degree was obtained. Hence, our results likely provide a lower bound compared to a scenario where all states introduced tuition fees simultaneously, given that around 70% of students in our study attend university in the state where they completed high school. This issue is discussed further in Section 5.4, where we also present empirical results for an upper bound. Second, students who enrolled in treated states before the introduction of tuition fees were still required to pay fees if these were implemented during their university studies. As a result, some individuals in the control cohorts may have encountered tuition fees later in their academic career, though not at the usual time of enrolment. To address this, we assess the robustness of our findings by excluding the final school-leaving cohorts before tuition fees were introduced. Third, our data do not allow us to observe who actually paid tuition fees, and we know that certain subgroups of students, such as those with children or disabilities,

were exempt from tuition fees, but we cannot identify these groups within our dataset.

Since two states introduced tuition fees in 2006 and others in 2007, our setting features staggered treatment timing. In such cases, the two-way fixed effects (TWFE) estimator for Equation (2) may yield biased results if treatment effects vary over time or across groups, as highlighted by Goodman-Bacon (2021). To address this issue, we employ the estimators recently developed by de Chaisemartin and D'Haultfoeuille (2020), Sun and Abraham (2021), Callaway and Sant'Anna (2021), and Borusyak, Jaravel, and Spiess (2024). These estimators address the limitations of the TWFE estimator, avoiding the "forbidden comparisons" problem, where earlier-treated units are used as controls for later-treated units. Our findings show that the conclusions remain unchanged when using these more robust estimators.

5 Results

5.1 Main results

Column (1) in Panel A of Table 2 presents the results of our main specification, using the graduation rate as the outcome variable. This specification includes controls for the transition cohort as well as year and county fixed effects. The results indicate that tuition fees reduce the probability of graduating from university within eight years of enrolment by 1.8 percentage points (pp), an effect that is statistically significant at the 5% level. Given that approximately 36% of high-school leavers in our sample complete university within eight years after enrolment, the estimated effect corresponds to about 5% of this outcome mean. Turning to the enrolment rate in Panel B, we find that tuition fees significantly reduce the probability of university enrolment by 3.2 pp. This effect aligns closely with the results of other studies, which use slightly different data or specifications and report an estimated decline in enrolment rates of 2.7 to 4 pp (Hübner, 2012; Bietenbeck et al., 2023). Taken together, the results from Panels A and B suggest that among those who did not enrol due to tuition fees, 57.6% (=1.82/3.16) would have graduated, while 42.4% would not have

completed a degree in the absence of fees. The latter finding supports the notion that tuition fees help discourage ghost students.[13] However, the results also indicate that fees deter some students who would have successfully obtained a degree.

The remaining columns of Table 2 sequentially incorporate control variables to assess the robustness of our main findings. Column (2) includes economic controls reflecting the economic situation of the county in the year of leaving school, including the youth unemployment rate, GDP growth, the share of employees in the primary sector, and the share of employees in the secondary sector. Column (3) further introduces controls for the condition of the state's higher education system at the time of leaving school. These controls include the share of Bachelor's programmes among all programmes to account for potential differences in the implementation of the Bologna reform across states, and the share of programmes in (i) social sciences, (ii) STEM, and (iii) other study programmes out of all programmes to account for possible shifts in preferences for these subject groups over time. Column (4) adds controls related to the school-leaving cohort in a given county, including the proportion of female school leavers, the proportion of foreign school leavers, and a dummy for cohorts affected by the G8 or G9 reforms (see Section 2). Additionally, this specification controls for the number of high-school leavers per university in a given state to account for potentially divergent birth rates between fee and non-fee states over time. Such differences could result in varying competition for university enrolment, as discussed in Bruckmeier and Wigger (2014). The inclusion of all these control variables does not alter our main conclusions: the introduction of tuition fees significantly reduces the number of university graduates and this reduction is clearly smaller in absolute terms than the fee-induced reduction in enrolment rates.

Next, we conduct an event-study analysis to demonstrate that our results extend beyond the first two tuition fee cohorts and to assess the validity of our identification assumption. This assumption posits that, in the absence of tuition fees, graduation rates (and enrolment

[13]Dividing the 1.4 percentage point difference between the two effects by the outcome mean of the enrolment rate (57.1) results in an estimated share of ghost students at 2.5% of enrolled first-year students.

rates, respectively) would have followed the same trend in fee and non-fee states. While this counterfactual cannot be directly tested, we can evaluate its plausibility by checking for similar pre-trends in the outcome variable in Figure 2.

The figure reveals several striking patterns. First, none of the coefficients in the pre-treatment period are statistically significant for both the graduation rate (Panel A) and the enrolment rate (Panel B), suggesting that trends in the outcome variable were similar in treatment and control states before the introduction of tuition fees. Second, this changes once tuition fees are introduced. Consistent with the results in Table 2, tuition fees significantly reduce the graduation rate by nearly two percentage points and the enrolment rate by more than three percentage points. Third, these negative effects persist beyond the first two affected cohorts and even slightly increase in absolute terms for subsequent cohorts. The effects remain statistically significant at the 5% level for all cohorts, reaching reductions of up to 2.6 percentage points for graduation rates and 3.9 percentage points for enrolment rates by the fourth cohort. It is important to note that cohorts were exposed to tuition fees for varying lengths of time: while the first cohorts paid fees for the longest period, later cohorts were more likely to experience the abolition of fees during their studies. One possible explanation for the slight increase in the effect is that tuition fees provide an incentive for enrolled students to complete their studies more quickly, an incentive that is less pronounced for later cohorts (Bietenbeck et al., 2023) and which we will explore in Section 5.4. Fourth, the figure highlights the unique nature of the cohort at value "-1," the transition cohort. Students in this cohort did not face tuition fees in their first year if they enrolled immediately after high school but faced fees if they delayed enrolment by a year. Reflecting the mix of treated and untreated cohort members, the point estimates for this cohort fall between those of the pre-treatment and treated cohorts.[14]

[14]Given the ambiguous treatment status of this cohort, we exclude it from the treatment and control groups in our main specification. Instead, we include the indicator $TransitionCohort_{d_c}$ in Equation (2) to account for this cohort.

5.2 Robustness checks

We begin by assessing the robustness of our results using DiD estimators designed to account for treatment effect heterogeneity in settings with staggered treatment. Table 3 reports results for four of these alternative estimators (de Chaisemartin and D'Haultfoeuille, 2020; Sun and Abraham, 2021; Callaway and Sant'Anna, 2021; Borusyak, Jaravel, and Spiess, 2024) in columns (2)–(5), alongside our main specification in column (1). All estimators confirm our findings, yielding point estimates close to those of the two-way fixed effects estimator and statistical significance at the 5% level. This suggests that any potential bias due to treatment effect heterogeneity in our setting is minimal.

Next, we assess the robustness of our results to alternative sample selection decisions. Figure A.3 shows results when varying the timeframe for enrolment beyond the year of school leaving or the following year, while Figure A.4 explores alternative starting cohorts from 1995 to 2002. To account for pre-treatment cohorts that enrolled before the introduction of tuition fees but paid fees during part of their studies, we exclude up to three cohorts prior to the transition cohort in the "doughnut" specifications of Figure A.5. Figure A.6 shows the results when excluding individual states. Our results remain robust across all these specifications.

Similarly, Table 4 shows that our results are robust to further alternative sample restrictions. Column (2) excludes Saxony-Anhalt and Mecklenburg-West Pomerania from the control states, as these states implemented both the abolition and subsequent reintroduction of the G8 reform (see Section 2.3). Column (3) presents the results when including Saarland and Hesse, while Column (4) expands the sample to include degrees from technical colleges and all school leavers eligible for enrolment in higher education.[15] Across these alternative specifications, the significance and magnitude of the effects remain largely unchanged.

In summary, the findings in this section demonstrate that our results are robust to alter-

[15]Unlike the main specification, the analyses including Saarland and Hesse, as well as those including technical colleges (without dual study programme institutions), are conducted at the state-year level rather than the county-year level due to data limitations for these states and for high-school leavers with technical college entrance qualifications.

native estimation methods as well as to variations in the definition of the outcome variable, the observation period, and the sample selection criteria.

5.3 Treatment effect heterogeneity

This section examines how the effect of tuition fees varies across individual and regional characteristics. We start by analysing heterogeneity by fields of study as the first individual-level characteristic. Following Bietenbeck et al. (2023), we classify fields into humanities, social sciences, STEM, and other fields.[16] The results in columns (1) to (4) in Panel A of Figure 5 show a negative effect of tuition fees on graduation across all fields of study except STEM. The effect is statistically significant for social sciences and "other fields." Compared to the outcome means, the declines in graduation rates are similar for humanities and social sciences, with a more pronounced reduction in "other fields." A potential explanation for the lack of impact of tuition fees on STEM graduation rates is the higher lifetime earnings associated with STEM degrees (see, e.g., Webber, 2014; Altonji, Arcidiacono, and Maurel, 2016), which make the cost of tuition fees less burdensome compared to fields with lower earning potential. The difference between STEM and other fields is unlikely to be driven by differences in drop-out or switching behaviour between fields, as it is already apparent at the enrolment stage (see Panel B).

Second, we estimate our main specification, Equation (2), separately for men and women. Columns (5) and (6) of Table 5 indicate that women are more affected by tuition fees than men. For men, the effect of tuition fees on university graduation is smaller in absolute terms and statistically insignificant. Although the mean outcome variable is higher for women (38% vs. 34% who completed university within eight years of enrolment), the relative effect size, expressed as a fraction of the outcome mean, is also considerably larger for women. We also observe gender differences in the effect of tuition fees on the enrolment rate (Panel B):

[16] To investigate this, we redefine the outcome variable as the number of university graduates in a specific field within each county-cohort cell, divided by the number of high-school leavers in the same county-cohort cell. This approach retains the denominator from Equation (1) but adjusts the numerator to include only university degrees awarded in the specified field.

women experience a decline of 3.6 percentage points, compared to a 2.5 percentage point decline for men. This suggests that the larger reduction in graduation rates for women partly stems from a greater sensitivity to tuition fees at the enrolment stage. Comparing the results from Panels A and B reveals that among men, 41.9% (=1.06/2.53) of those who did not enrol due to tuition fees would have graduated in the absence of fees, while among females this share is 68.4% (=2.49/3.64). Consequently, 58.1% of men and 31.6% of women who did not enrol due to tuition fees would not have graduated even in the absence of tuition fees, suggesting a higher proportion of ghost students among men. To explore gender-specific dynamics over time, we analyse separate event study graphs for men and women (Figure A.7). Reassuringly, both genders exhibit no differential pre-trends between treated and control groups. Interestingly, the more pronounced effect observed for women is not attributable to a single cohort but instead shows a gradual increase over time.[17]

One explanation for the more negative graduation effect for women is that men and women choose different fields of study, and the impact of tuition fees varies across these fields. Indeed, we find evidence supporting this: among graduates, women make up 77% in the humanities, 69% in other subjects, and 61% in the social sciences. For all three fields, we observe negative effects of tuition fees on graduation rates in Table 5. Interestingly, in STEM fields, where male graduates outnumber females (55% vs. 45%), there is no observed negative effect of tuition fees on graduation.[18] This suggests that the field of study is a key factor driving the gender differences in the effect of tuition fees. Consistent with this argument, we observe smaller or no gender differences in the tuition fee effect when analysing the fields of study separately (see Table A.2).

Next, we explore whether the treatment effect varies with county characteristics. While our administrative data lack individual-level measures of socio-economic status (SES), we

[17]Notably, the coefficient for the transition cohort is larger for men, which aligns with expectations. Men in this cohort are less likely to enrol immediately in university due to military service, meaning they faced tuition fees in their first year. In contrast, women in the transition cohort were not subject to tuition fees in their first year if they enrolled immediately after high school.

[18]These proportions are similar but 2–3 percentage points lower for enrolment (74%, 67%, 58%, 43%), indicating that males are more likely to leave university without completing a degree.

use county-level characteristics as proxies to investigate whether the impact of tuition fees differs based on SES. Specifically, we categorise counties based on GDP per capita, SES structures, and population density.[19] The results in Table 6 indicate that the negative effects of tuition fees are more pronounced in counties with lower GDP per capita, weaker SES structures, and lower population density. These findings suggest that SES-related characteristics might amplify the impact of tuition fees, with economically disadvantaged regions being disproportionately affected. Although the observed differences are not statistically significant, likely due to the limitations of using aggregated county-level proxies for SES, they align with the findings of Bahrs and Siedler (2019), who, based on survey data, show that tuition fees primarily reduce the intention to study among individuals from low-income households. Interestingly, the difference between the graduation and enrolment effects is less pronounced in counties with lower GDP per capita, weaker socioeconomic structures, and lower population density, suggesting that in these counties, most of the deterred students would have likely graduated from university. In contrast, in more affluent counties, the gap between graduation and enrolment is wider, indicating that many of the deterred students would not have graduated if tuition fees had not been introduced, implying a higher prevalence of ghost students in these areas. We also perform the heterogeneity analysis by county characteristics separately for men and women. While the effect for women is constant across all kind of heterogeneities (see Figure A.8a), men are significantly affected in rural areas, or in disadvantaged counties while the effect is close to zero in cities and wealthier counties.

We further examine the heterogeneity of the treatment effect at the state level. As shown in Figure 3, the overall negative effect of tuition fees on graduation is not driven by any single state, underscoring that this is a broader phenomenon rather than a state-specific issue.[20] Notably, the point estimates are negative for all five treatment states in our sample, providing consistent evidence of the adverse impact of tuition fees across the affected states.

[19]For each dimension, counties are split at the median: (i) GDP per capita prior to the introduction of tuition fees, (ii) the 2006 regional SES ranking, and (iii) population density.

[20]Figure 3 is based on a modified version of Equation (2), where the single overall treatment indicator is replaced with separate treatment indicators for each treated state.

5.4 Further results

This section presents additional results relating to student mobility and the timing of graduation.

Student mobility

In our main specification, we assign the treatment indicator on the basis of the year and county (and thus state) of school leaving, while we measure university graduation and enrolment regardless of the state in which the degree was obtained. Hence, we do not impose restrictions on the state of enrolment or graduation, which allows for mobility across state borders. On the one hand, this allows school leavers from fee states to avoid paying fees by moving to a non-fee state. On the other hand, school leavers from non-fee states who would prefer to study in a fee state could be deterred from doing so by the fees. Since about 70% of students in our sample study in the state in which they completed high school, our results represent a lower bound compared to the situation in which all states charge tuition fees.[21] We provide two empirical approaches to investigate the impact of mobility for our estimates and provide an estimate for the treatment effect if all states introduced tuition fees.

First, we exploit the fact that some treated counties have a border with a non-fee state. High-school leavers in these counties can avoid paying tuition fees by moving a few kilometres to the neighbouring state, or even staying in their home state and travelling a short distance to the neighbouring state. We would therefore expect these counties to be less affected by tuition fees than others. In total, 32 of the 236 counties in our tuition fee states have a border with a non-tuition fee state (see Figure A.1). Columns (1) and (2) of Table 7 show the results when estimating our main specification separately for treated counties with and without a border to a non-fee state. In line with our expectations, the overall effect of tuition fees is driven by counties without a border to a non-fee state. We estimate that tuition fees reduce

[21] Hübner (2012) outlines the assumption for such a bounding exercise in more detail. After estimating a similar lower bound of the reduction in enrolment by 2.8 pp with slightly different data and sample restrictions, he introduces a theoretical model of university enrolment and calculates an approximation of the true average treatment effect of roughly 5 pp and an upper bound of roughly 7 pp, which is comparable with the effect for a nation-wide introduction of tuition fees.

the graduation rate by 2.05 pp in counties without a border to a non-fee state, while the effect for counties with a border to a fee state is smaller at -0.67 and statistically insignificant. Similarly, Panel B shows that these differences are already present at the enrolment stage. This is also in line with the results of Dwenger, Storck, and Wrohlich (2012), who find that tuition fees decrease in the probability of applying for a university in the home state by 2 pp. When distinguishing between men and women (see Figure A.8b), we find that, particularly in border counties, men show no effect. This aligns with the findings of Boelmann (2024) that men are more geographically mobile in pursuit of higher education.

Second, we construct an alternative outcome variable using the same denominator as in Equation (1), but aggregated at the state level. The numerator includes all individuals from a given cohort who graduated (Panel A) or enrolled (Panel B) in a particular state, regardless of where they obtained their university entrance qualification.[22] While our main specification accounts for migration and should therefore be interpreted as a lower bound, the alternative outcome variable provides a proxy estimate under the assumption that all states introduced tuition fees, offering an upper bound for the effect. Columns (3) - (6) of Table 7 show the effect of estimating Equation (2) with the new outcome variable at the state year level with state and year fixed effects in column (3) and after the inclusion of control variables in columns (4) - (6). The graduation effect is between 2.8 and 3.4 pp in all specifications, robust to the inclusion of control variables and statistically significant for the graduation rate. For the enrolment rate, the effect increases to around 5 pp (see Panel B), which is very close to the calculations of Hübner (2012) in his theoretical framework. Overall, this suggests that we slightly underestimate the true average treatment effect because of mobility but also that mobility does hardly change our general findings.

[22]It is important to note that, in this case, the number of school leavers in state k in the denominator does not directly correspond to the number of university graduates/enrollees in state k due to student mobility. However, since most school leavers choose to study in their home state, they still represent a reasonable at-risk population.

Study incentives

To further study if tuition fees change the incentives when already enrolled, we examine their effect on graduation within different time frames. While our main specification focuses on graduation within eight years of enrolment, capturing nearly all graduates, Figure 4 illustrates the impact of tuition fees on graduation within 3 to 10 years after enrolment. The results indicate that tuition fees promote faster graduation, with positive and statistically significant effects for graduation within 3, 4, and 5 years. Beyond 5 years, the coefficients turn negative, stabilising after 7 years. An analysis of graduation after an exact number of years supports these findings, suggesting that tuition fees incentivise students to complete their studies more quickly. The effects for graduation after 8 or more years serve as a placebo check, since students in the treatment states who took this long were subject to long-term student fees even before the introduction of general tuition fees (see Section 2). Significant effects for graduation after 8 or more years would suggest other factors, such as shocks or policies, influencing the outcome variable differently in treatment and control states. Reassuringly, these placebo effects are close to zero and statistically insignificant, supporting the common trends assumption. When performing the same analysis separately for men and women (Figure A.9), it is notable that the incentive to study faster appears to be more effective for men than for women. As before, it is reassuring that the placebo effects for graduating after exactly 8 years or more are small and statistically insignificant for both genders.

6 Discussion and Conclusion

An important policy question is who should bear the costs of higher education and whether and how much students should contribute privately to the cost of their education. Against this background, this study investigates the impact of tuition fees on university graduation. Using the staggered introduction of tuition fees in Germany as a natural experiment, we find

that while fees reduce university enrolment by 3.2 percentage points, the effect on graduation is less pronounced at 1.8 percentage points. This suggests that a considerable proportion of high-school leavers deterred by fees would not have graduated even in their absence, highlighting the potential role of tuition fees in discouraging ghost students—individuals who enrol in higher education primarily for non-educational benefits.

Our findings also reveal significant heterogeneities: women are more affected by tuition fees than men, possibly due to their lower representation in STEM fields, which offer higher earnings potential and show no negative graduation effects. Additionally, the adverse effects of fees are more pronounced in economically disadvantaged counties, highlighting the risk of exacerbating socio-economic inequalities. Interestingly, our results indicate that economically disadvantaged counties have a low proportion of ghost students and, consequently, play only a minor role in the positive impact of tuition fees on reducing unwanted enrolments. Importantly, our estimates suggest a lower bound compared to a scenario where all states implement tuition fees, reinforcing the robustness of our results.

Our contributions to the literature are threefold. First, we provide evidence on the effects of tuition fees on university graduation, a more critical outcome than enrolment alone. Second, we shed light on the no-fee-to-fee margin, which is particularly relevant for countries with zero tuition fees that are contemplating their introduction and for countries with tuition fees that are considering their abolishment. Finally, we draw attention to the issue of ghost students, an underexplored yet economically and administratively significant phenomenon.

From a policy perspective, our study provides several key insights. Even relatively modest tuition fees, by international standards, reduce university graduation rates, resulting in both individual and societal welfare losses. This decline in graduation rates is particularly concerning because our findings indicate that students from disadvantaged backgrounds are disproportionately affected, suggesting that tuition fees may exacerbate socio-economic disparities. However, the impact of tuition fees is not as detrimental as previously assumed,

as a substantial share of high-school leavers deterred from enrolling would not have graduated even in the absence of fees. This nuanced finding highlights the dual nature of tuition fees: while they can effectively discourage ghost students, they also deter some individuals who would have successfully completed their degrees. Therefore, alternative strategies for addressing the issue of "ghost students" merit further consideration. For example, introducing minimum study performance requirements—such as passing a certain number of courses within a specified timeframe—could be a promising approach. Austria implemented such a system in 2022 (Federal Ministry of Education, Science and Research Austria, 2022). Similarly, introducing fees for students who fail to complete any courses within a set period could help deter prolonged enrolment without academic progress. More generally, policymakers must carefully balance the different trade-offs when designing tuition fee systems. Complementary measures, such as targeted financial aid, income-contingent repayment schemes (see, e.g., Murphy, Scott-Clayton, and Wyness, 2019), or information campaigns on the long-term benefits of higher education (see, e.g., Bettinger et al., 2012; Barr and Turner, 2018), could help mitigate adverse effects while preserving the efficiency gains associated with discouraging ghost students.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data and Code Availability

This paper uses confidential microdata from the Research Data Centres (RDCs) of the German Statistical Offices. Access to the data is subject to the terms and conditions of the RDCs: `https://www.forschungsdatenzentrum.de/en/terms-use`. We are willing to provide guidance on how to acquire the data. Replication code will be made available once the paper is accepted for publication.

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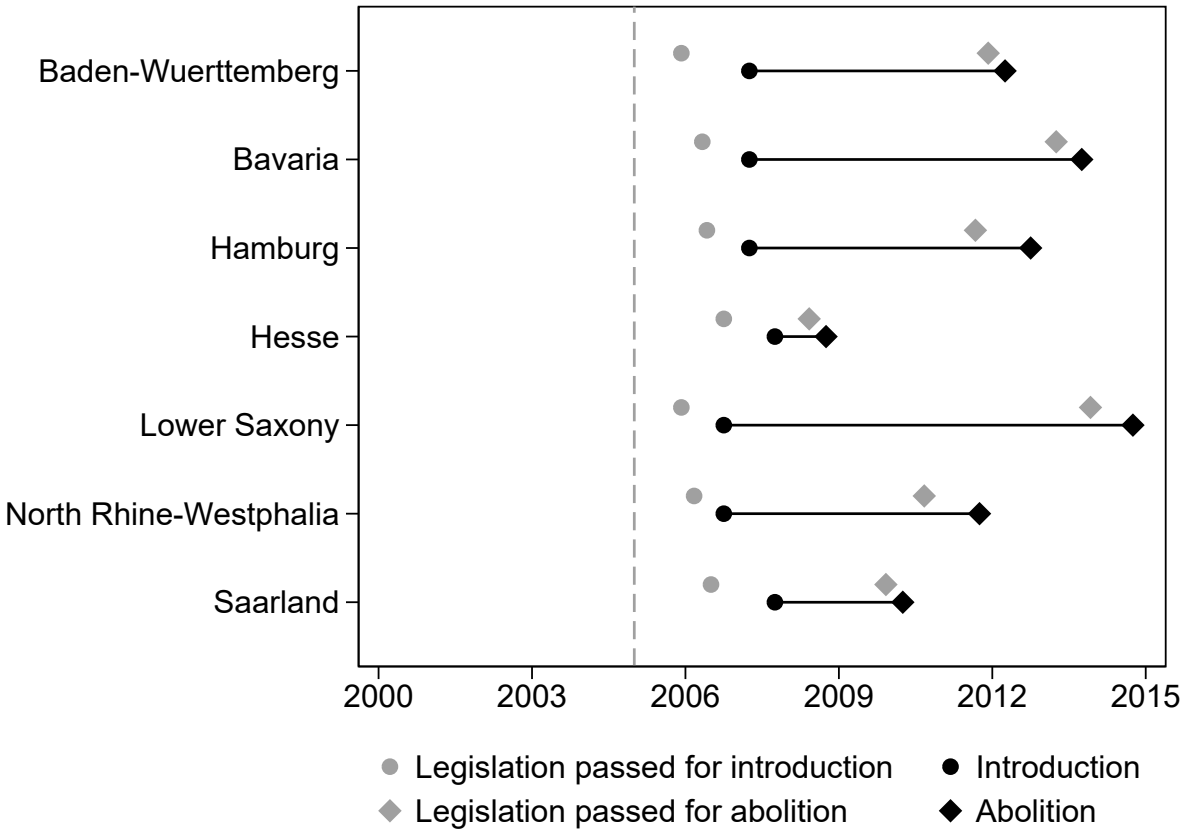
7 Figures

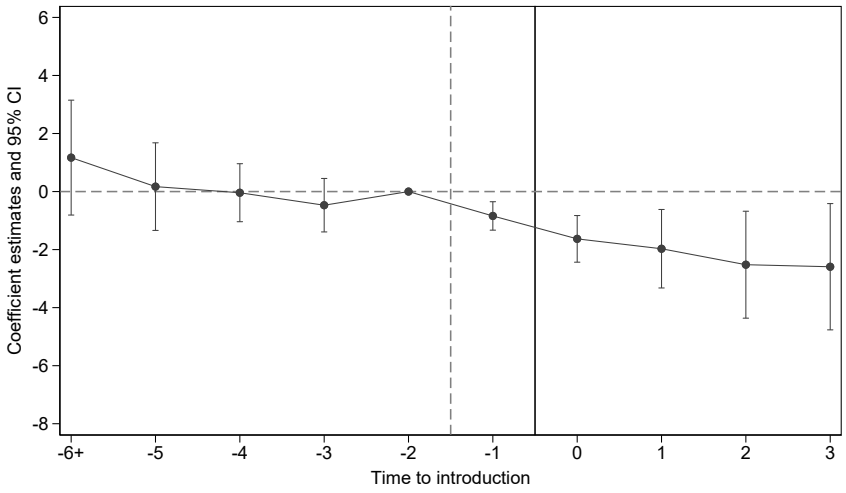
Figure 1: Introduction and abolition of tuition fees



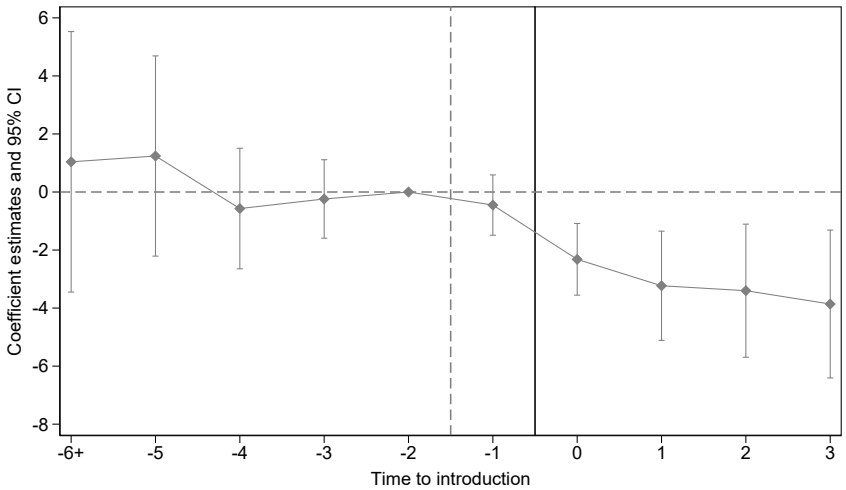
Notes: The figure illustrates the timeline for the introduction and abolition of general tuition fees in the seven German states that implemented fees. The vertical line marks the date on which the Federal Constitutional Court overturned the ban on tuition fees. For each state, the figure shows the dates of legislation introducing and abolishing tuition fees (represented by a grey dot and a grey diamond, respectively) and the period during which tuition fees were in effect (depicted from a black dot to a black diamond). Further details are provided in Table A.1.

Figure 2: Event-study – The effect of tuition fees on university graduation and enrolment

(a) Graduation

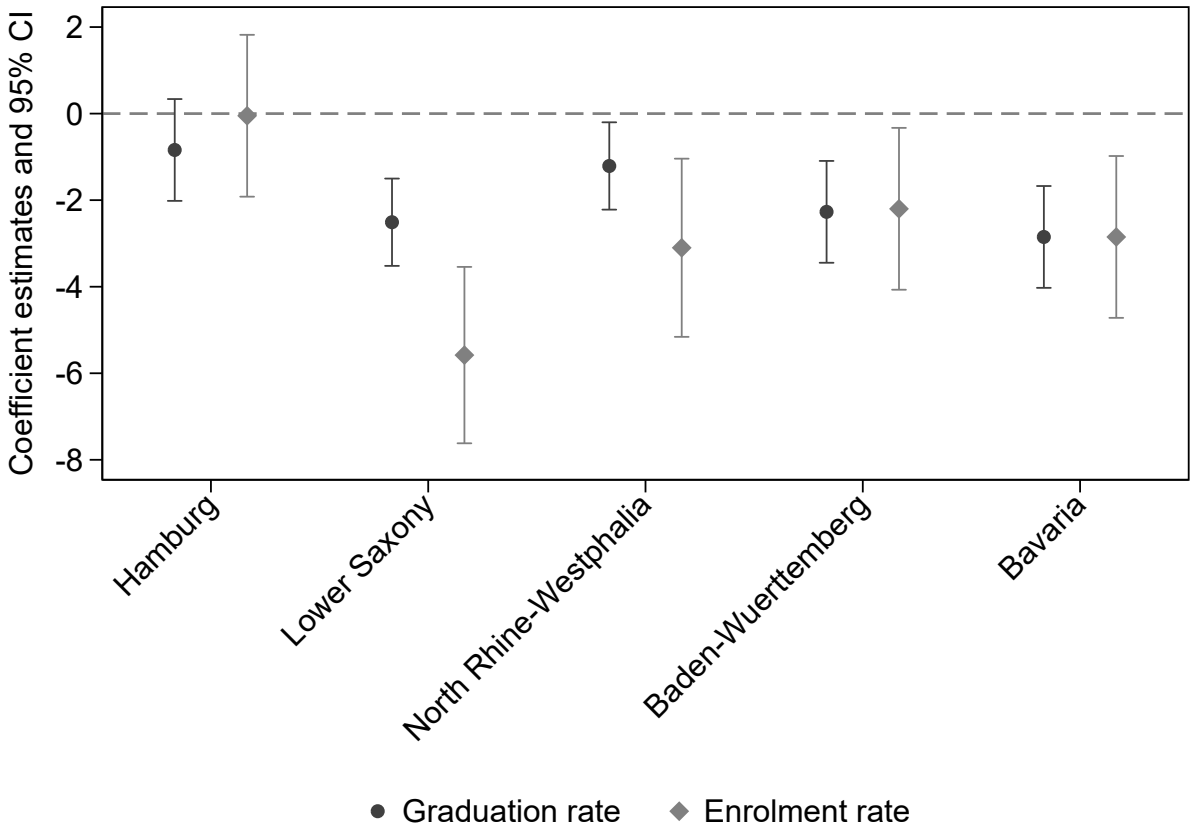


(b) Enrolment



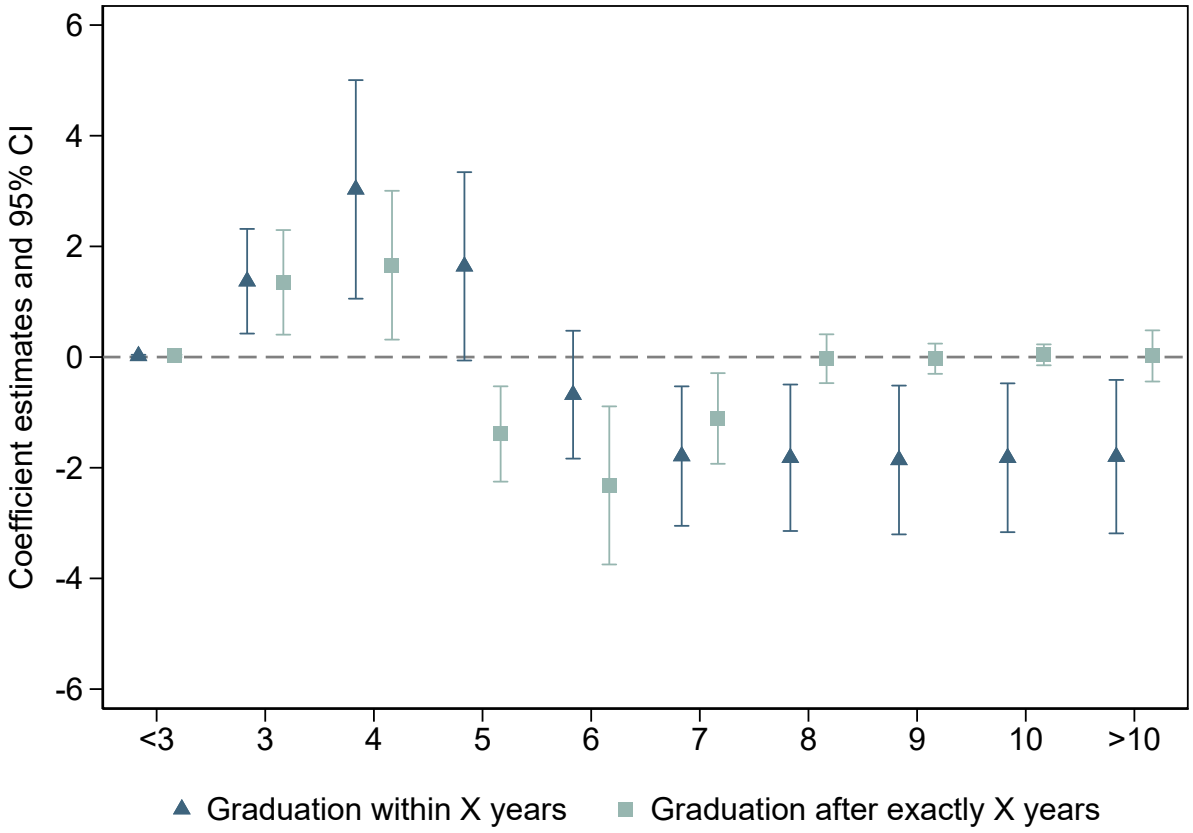
Notes: The figure displays point estimates and 95 per cent confidence intervals for the cohort-specific effects of tuition fees on graduation (Panel A) and enrolment rates (Panel B), based on difference-in-differences event-study regressions. The solid line indicates the introduction of tuition fees in the first year, while the dashed line corresponds to the transition cohort. This cohort is not classified as either treated or control, as they did not have to pay tuition fees in their first year if they enrolled immediately after high school but were required to pay fees in their first year if they delayed enrolment by one year.
Panel A is based on an event-study regression with the estimation equation: $G_{d,c} = \sum_i \beta_i * Fee_{d,c} + \gamma_d + \delta_y + \varepsilon_{d,c}$.This equation extends Equation (2) in two ways. First, instead of a single treatment indicator, it includes leads and lags of the treatment indicator to capture the dynamic effects of tuition fees. Two periods before the introduction of tuition fees are used as the reference period, given the ambiguous treatment status of the transition cohort at -1. Second, the analysis expands the sample to include high-school leavers from 2000 to 2010, rather than just 2000 to 2008, allowing for an assessment of the impact of tuition fees on subsequent cohorts. The computations for panel B follow analogously. Confidence intervals are constructed using standard errors clustered at the state level.

Figure 3: State-specific effects of tuition fees



Notes: The figure presents point estimates and 95 per cent confidence intervals for the effect of tuition fees on graduation (black dots) and enrolment rates (grey diamonds), shown separately for each treated state. The specification is based on Equation (2), with the general Fee indicator replaced by separate fee indicators for each of the five treated states in our main sample.

Figure 4: The effect of tuition fees on the timing of graduation



Notes: The figure presents point estimates and 95 per cent confidence intervals for the effect of tuition fees on university graduation within X years (dark blue triangles) and exactly after X years (light blue squares) for different study durations (X). The dark blue triangle for $X = 8$ years repeats the estimated treatment effect from our main specification, while the other dark blue triangles illustrate the impact of tuition fees on graduation within 3 to 10 years after enrolment. The light blue squares represent the effect of tuition fees on graduation precisely after the specified number of years. Each triangle and square corresponds to a separate estimate of the tuition fee effect based on Equation (2), differing only in the definition of the outcome variable.

8 Tables

Table 1: Descriptive statistics of school leavers and university graduates

Variable	Mean	SD
High-school leaver characteristics		
Cohort	2004.0	2.2
Female	56.3	3.6
Treatment		
School completion in state that introduced fees	61.1	48.8
Treated cohorts	16.1	36.8
Outcomes		
University graduation	36.4	9.4
University enrolment	57.1	11.5
University graduate characteristics		
Female	58.9	4.5
Subject		
- Humanities	20.9	5.0
- Social Sciences	32.4	5.7
- STEM	39.7	5.1
- Other	6.8	2.4

Notes: The table presents the means and standard deviations of key variables in our data, based on information from 1,853,320 school leavers and 674,432 university graduates included in our main estimation sample.

Table 2: Main results – The effect of tuition fees

	Main	Robustness		
	(1)	(2)	(3)	(4)
Panel A: Graduation rate				
Tuition fees	-1.82**	-1.75**	-1.61**	-1.95**
	(0.63)	(0.58)	(0.66)	(0.66)
Outcome mean		36.4		
Panel B: Enrolment rate				
Tuition fees	-3.16***	-3.06***	-3.13***	-3.42***
	(0.99)	(0.97)	(1.03)	(1.06)
Outcome mean		57.1		
$N_{county*cohort}$	3,187	3,187	3,187	3,187
$N_{HS-Leavers}$	1,853,320	1,853,320	1,853,320	1,853,320
Year FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Transition cohort	Yes	Yes	Yes	Yes
Economic controls	No	Yes	Yes	Yes
University controls	No	No	Yes	Yes
High school controls	No	No	No	Yes

Notes: The table shows the effect of tuition fees on the probability of having graduated from university (Panel A) and of having enrolled at university (Panel B). All specifications include fixed effect for the year and the county of leaving school as well as for the transition cohort. Columns (2) to (4) include additional control variables, as indicated in the table footer. The equation is estimated at the county-cohort level, with the number of cells specified in row $N_{county*cohort}$, weighted by the number of high-school leavers to recover coefficients equivalent to those from an individual-level regression, with the number of observations specified in row $N_{HS-Leavers}$. Robust standard errors, clustered at the federal state level, are reported in parentheses (* $p<0.1$, ** $p<0.05$, *** $p<0.01$).

Table 3: Robustness checks – Staggered treatment estimators

	TWFE (Main) (1)	Chaisemartin and d'Haultfoeuille (2)	Sun and Abraham (3)	Callaway and Sant'Anna (4)	Borusyak et al. (5)
Panel A: Graduation rate					
Tuition fees	-1.82**	-1.76**	-1.93***	-1.99***	-1.96***
	(0.63)	(0.69)	(0.56)	(0.56)	(0.53)
Outcome mean			36.4		
Panel B: Enrolment rate					
Tuition fees	-3.16***	-2.30**	-3.04***	-2.68***	-3.06***
	(0.99)	(1.15)	(1.02)	(0.81)	(0.96)
Outcome mean			57.1		
$N_{county*cohort}$	3,187	3,187	3,187	3,187	3,187
$N_{HS-Leavers}$	1,853,320	1,853,320	1,853,320	1,853,320	1,853,320
Year FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes
Transition cohort	Yes	Yes	Yes	Yes	Yes

Notes: The table shows the effect of tuition fees on the probability of having graduated from university (Panel A) and of having enrolled at university (Panel B). While column (1) repeats our main specification applying the classical two-way fixed effects estimator, columns (2) to (5) show the average treatment effects of the treated (ATT) for different estimators that are robust to treatment effect heterogeneity in settings with staggered treatment adoption. All specifications include fixed effect for the year and the county of leaving school as well as for the transition cohort. The estimations are based on 3,187 county-cohort observations, corresponding to 1,853,320 high-school leavers. However, some of the alternative estimators rely on fewer observations as they avoid the forbidden comparisons. Robust standard errors, clustered at the federal state level, are reported in parentheses (* $p<0.1$, ** $p<0.05$, *** $p<0.01$).

Table 4: Robustness checks – Sample restrictions

	Main	Without MV and SH	Including HE and SL	With technical colleges
	(1)	(2)	(3)	(4)
Panel A: Graduation rate				
Tuition fees	-1.82**	-1.75**	-1.64***	-1.28**
	(0.63)	(0.77)	(0.55)	(0.44)
Outcome mean	36.4	37.0	36.6	36.8
Panel B: Enrolment rate				
Tuition fees	-3.16***	-3.41**	-2.87***	-1.30
	(0.99)	(1.14)	(0.91)	(0.78)
Outcome mean	36.4	37.0	36.6	36.8
$N_{county*cohort}$	3,187	2,989		
$N_{state*cohort}$			124	142
$N_{HS-Leavers}$	1,853,320	1,726,335	2,030,610	3,036,761
Year FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Transition cohort	Yes	Yes	Yes	Yes

Notes: The table shows the effect of tuition fees on the probability of university graduation (Panel A) and university enrolment (Panel B) under different sample restrictions. Column (1) repeats the results from the main specification. Column (2) excludes the states of Saxony-Anhalt (ST) and Mecklenburg-West Pomerania (MV), while Column (3) incorporates the states of Hesse (HE) and Saarland (SL). Column (4) broadens the sample to include degrees from technical colleges and all school leavers eligible for higher education enrolment. Columns (3) and (4) are estimated at the state-cohort level due to data restrictions. All specifications control for fixed effects related to the year and county/state of high-school completion, as well as for the transition cohort. Robust standard errors, clustered at the federal state level, are reported in parentheses (* $p<0.1$, ** $p<0.05$, *** $p<0.01$).

Table 5: Effect heterogeneity – Individual-level characteristics

	Subject				Gender	
	Humanities	Social Science	STEM	Other	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Graduation rate						
Tuition fees	-0.54	-1.05*	0.18	-0.36***	-2.49***	-1.06
	(0.34)	(0.51)	(0.48)	(0.10)	(0.73)	(0.85)
Outcome mean	7.6	11.8	14.5	2.5	38.1	34.2
Panel B: Enrolment rate						
Tuition fees	-0.84	-1.54**	-0.39	-0.36**	-3.64**	-2.53**
	(0.61)	(0.71)	(0.49)	(0.16)	(1.29)	(1.02)
Outcome mean	12.5	18.0	23.2	3.4	56.5	57.7
$N_{county*cohort}$	3,187	3,187	3,187	3,187	3,187	3,187
$N_{HS-Leavers}$	1,853,320	1,853,320	1,853,320	1,853,320	1,043,974	809,346
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Transition cohort	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table examines the heterogeneity in the effect of tuition fees on the probability of university graduation (Panel A) and university enrolment (Panel B). The first four columns present results for graduation and enrolment across different fields of study, as specified in the column headers. Column (5) reports the effects separately for women, while column (6) focuses on men. All specifications include fixed effects for the year and county of high-school completion, as well as for the transition cohort. Robust standard errors, clustered at the federal state level, are reported in parentheses (* $p<0.1$, ** $p<0.05$, *** $p<0.01$).

Table 6: Effect heterogeneity – County-level characteristics

	Population density		Regional ranking		GDP per capita	
	Rural	Urban	Low	High	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Graduation rate						
Tuition fees	-3.28***	-1.37**	-2.89**	-1.45**	-2.43**	-1.65**
	(0.56)	(0.56)	(0.97)	(0.56)	(0.55)	(0.55)
Outcome mean	35.0	34.8	34.5	35.2	34.3	35.3
Panel B: Enrolment rate						
Tuition fees	-3.40**	-2.96***	-3.13*	-3.11**	-3.28**	-3.05**
	(1.36)	(0.97)	(1.49)	(1.05)	(1.37)	(1.06)
Outcome mean	54.0	56.3	54.0	56.4	54.2	56.3
$N_{county*cohort}$	2,185	2,163	2,217	2,131	2,164	2,184
$N_{HS-Leavers}$	1,022,361	1,552,084	1,083,998	1,490,447	1,111,041	1,463,404
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Transition cohort	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table shows the effect of tuition fees on the probability of university graduation (Panel A) and university enrolment (Panel B) across different types of counties. The first two columns stratify the treated counties by population density, the next two columns by a regional ranking of socioeconomic status (SES), and the final two columns by GDP per capita. All specifications include fixed effects for the year and county of high-school completion, as well as for the transition cohort. Robust standard errors, clustered at the federal state level, are reported in parentheses (* $p<0.1$, ** $p<0.05$, *** $p<0.01$).

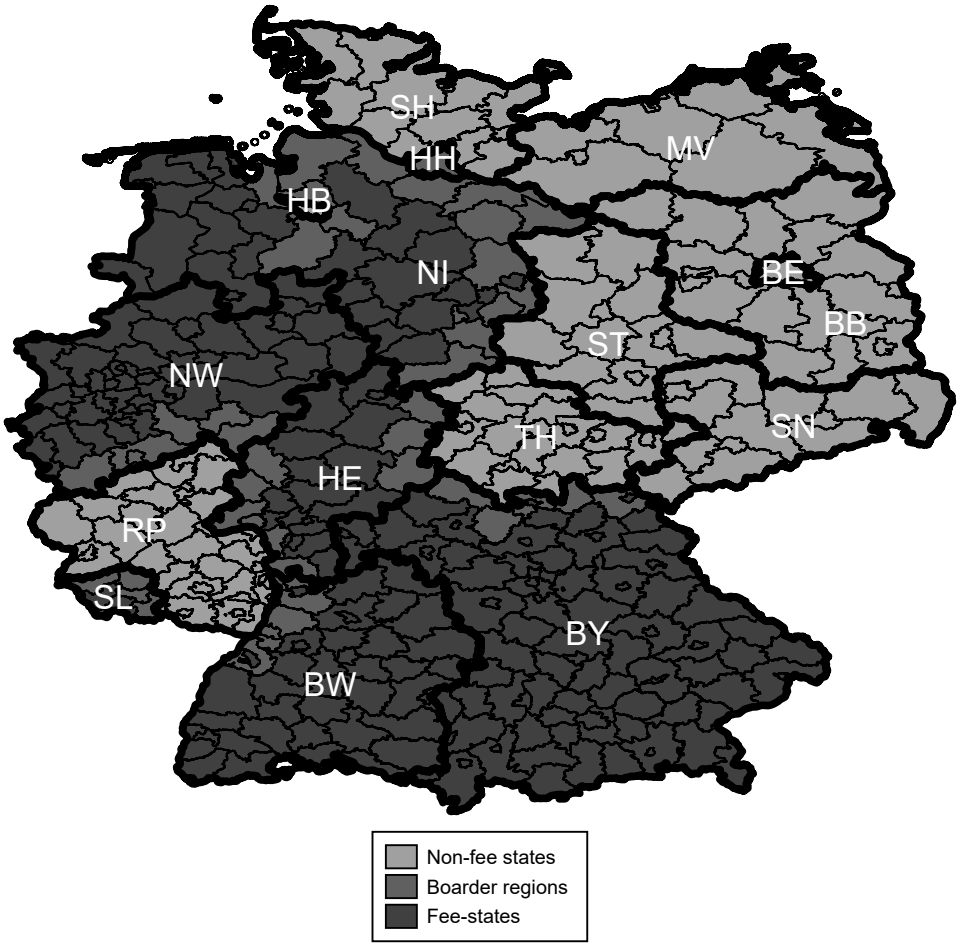
Table 7: Student mobility

	Boarder to non-fee state		Upper bound			
	Yes	No	Main	Robustness		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Graduation rate						
Tuition fees	-0.67	-2.05**	-3.12***	-3.42***	-2.93**	-2.77**
	(0.94)	(0.71)	(0.90)	(0.95)	(1.02)	(1.08)
Outcome mean	31.9	36.5		36.8		
Panel B: Enrolment rate						
Tuition fees	-0.97	-3.51***	-5.04**	-6.04**	-5.67**	-5.21*
	(1.80)	(0.97)	(2.27)	(2.11)	(2.51)	(2.58)
Outcome mean	51.9	57.2		57.4		
$N_{county*cohort}$	1,419	2,929				
$N_{state*cohort}$			124	124	124	124
$N_{HS-Leavers}$	887,676	1,686,769	1,855,379	1,855,379	1,855,379	1,855,379
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Transition cohort	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	No	No	No	Yes	Yes	Yes
University controls	No	No	No	No	Yes	Yes
High school controls	No	No	No	No	No	Yes

Notes: The table presents results related to student mobility. Columns (1) and (2) show the effect of tuition fees on the probability of university graduation (Panel A) and university enrolment (Panel B), distinguishing between treated counties with and without a border to a non-fee state. Columns (3) to (6) adopt an alternative definition of the treatment variable, providing a proxy estimate under the assumption that all states introduced tuition fees. Unlike our main specification, which considers all graduates/enrollees from a given county regardless of the state where they graduate or enrol, the outcome variable in these columns counts all graduates/enrollees within a given state, irrespective of where they completed high school. Column (3) follows our main estimation equation, Equation (2), while columns (4) to (6) gradually include additional control variables, consistent with those used in Table 2, as detailed in the table footer. All specifications include fixed effects for the year and county/state of high-school completion, as well as for the transition cohort. Robust standard errors, clustered at the federal state level, are reported in parentheses (* $p<0.1$, ** $p<0.05$, *** $p<0.01$).

9 Appendix A: Further results and information

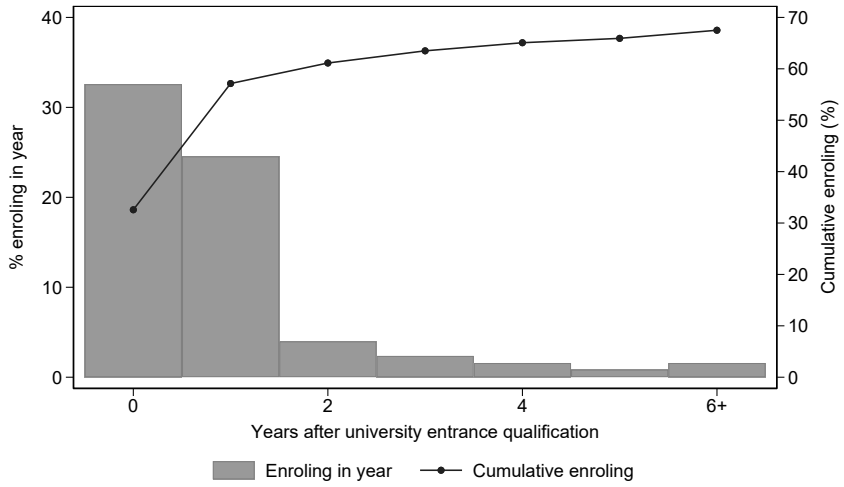
Figure A.1: Map of German counties



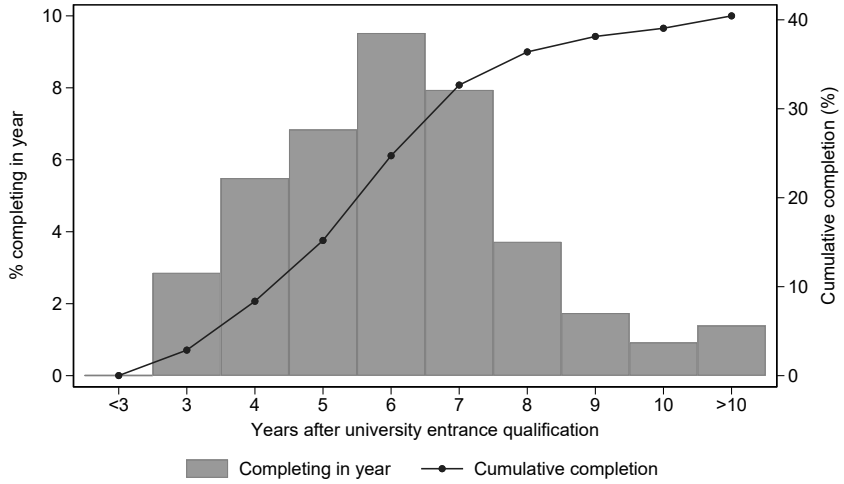
Notes: The figure displays the 16 German states and their division into 400 counties. Non-fee states are depicted in light grey, while fee states are shown in dark grey. Counties within fee states that share a border with non-fee states are highlighted in medium grey. Each state is labelled with its two-letter abbreviation, which corresponds to the abbreviations listed in Table A.1.

Figure A.2: Share of school leavers with university entrance qualification...

(a) ... enrolling at university

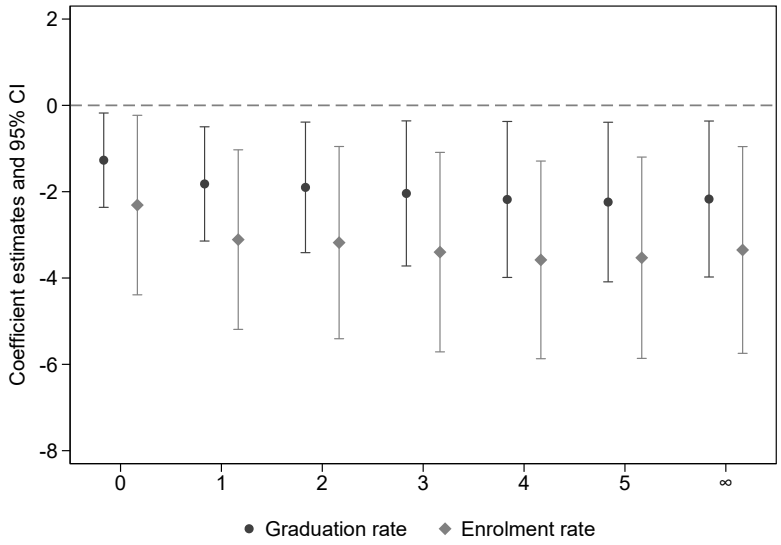


(b) ... completing university



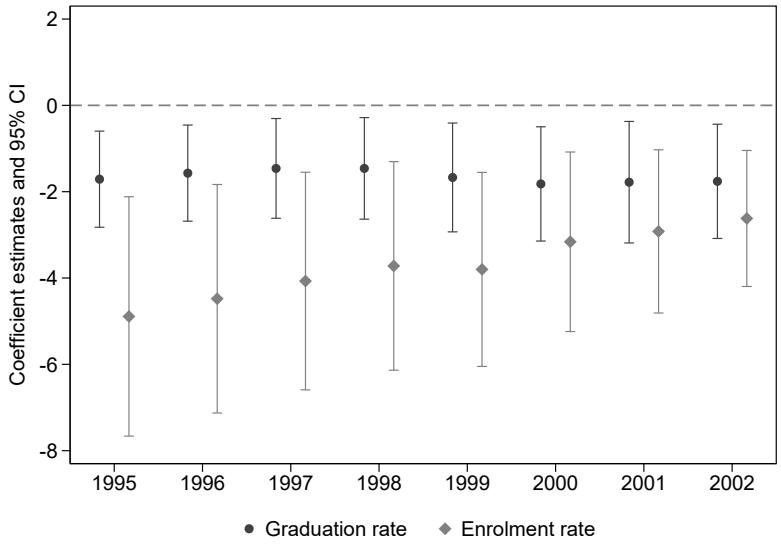
Notes: Panel A of the figure illustrates the proportion of high-school leavers who enrol in university within each of the first five years after leaving school or later (left axis), along with the cumulative enrolment rate over this period (right axis). Panel B presents the proportion of high-school leavers with enrolment up to one year after leaving school who complete their studies within each of the first ten years after enrolment (left axis), alongside the cumulative graduation rate over these years (right axis).

Figure A.3: Robustness test – Maximal time between high-school completion and enrolment



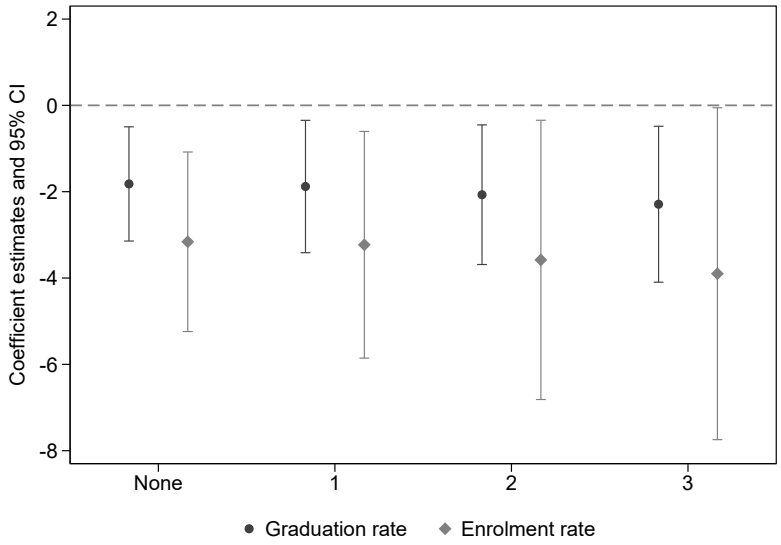
Notes: The figure presents point estimates and 95 per cent confidence intervals for the effect of tuition fees on graduation rates (black dots) and enrolment rates (grey diamonds), considering different maximum time intervals between high-school completion and university enrolment. Our main specification assumes a maximum gap of one year between leaving high school and university enrolment. All specifications are based on Equation (2); the only difference lies in the construction of the numerator of the outcome variable.

Figure A.4: Robustness test – Start of observation period



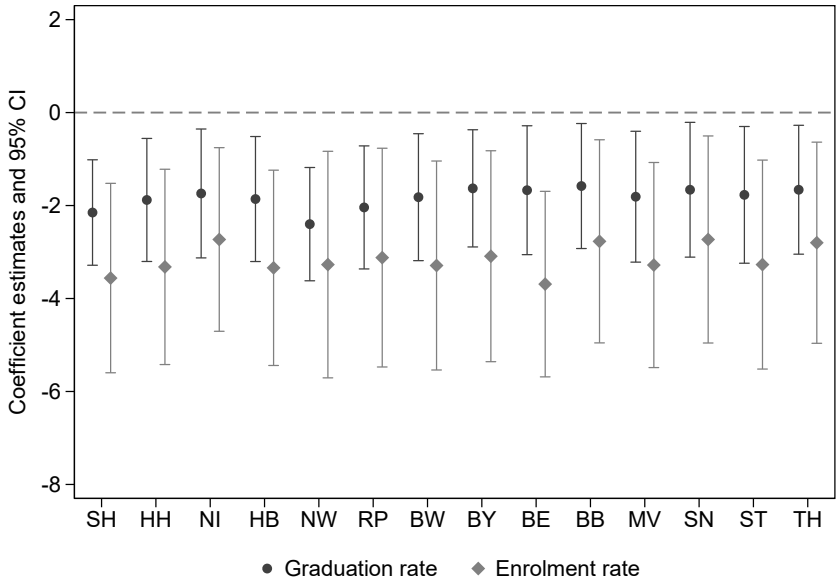
Notes: The figure presents point estimates and 95 per cent confidence intervals for the effect of tuition fees on graduation rates (black dots) and enrolment rates (grey diamonds), based on different starting years of the observation period. Our main specification uses the year 2000 as the start of the observation period. All specifications are based on Equation (2), differing only in the chosen starting year of the observation period.

Figure A.5: Robustness test – Leaving out cohorts before tuition fee introduction



Notes: The figure presents point estimates and 95 per cent confidence intervals for the effect of tuition fees on graduation rates (black dots) and enrolment rates (grey diamonds), excluding different numbers of cohorts before the transition cohort. While our main specification includes all high-school leaving cohorts from 2000 to 2007/08, here we exclude up to three cohorts prior to the transition cohort (the "doughnut" specifications). All specifications are based on Equation (2), differing only in the number of cohorts excluded before the transition cohort.

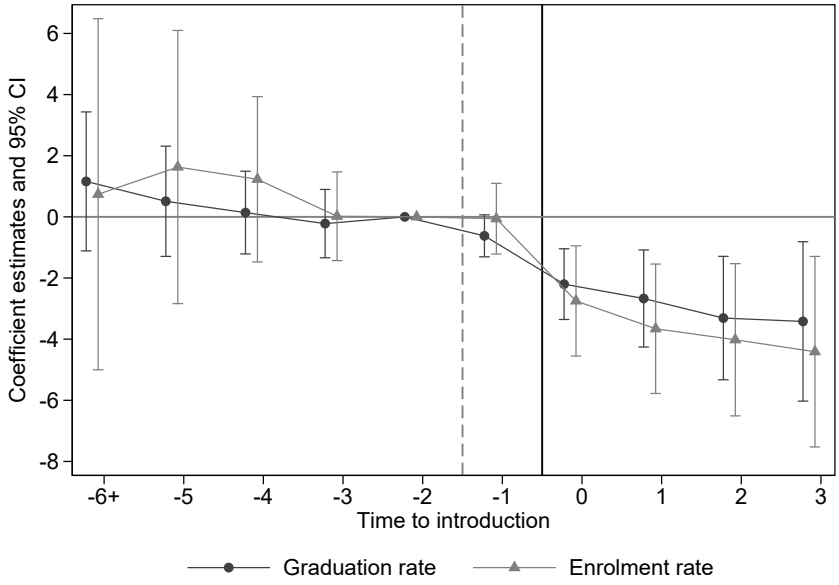
Figure A.6: Robustness test – Excluding each state



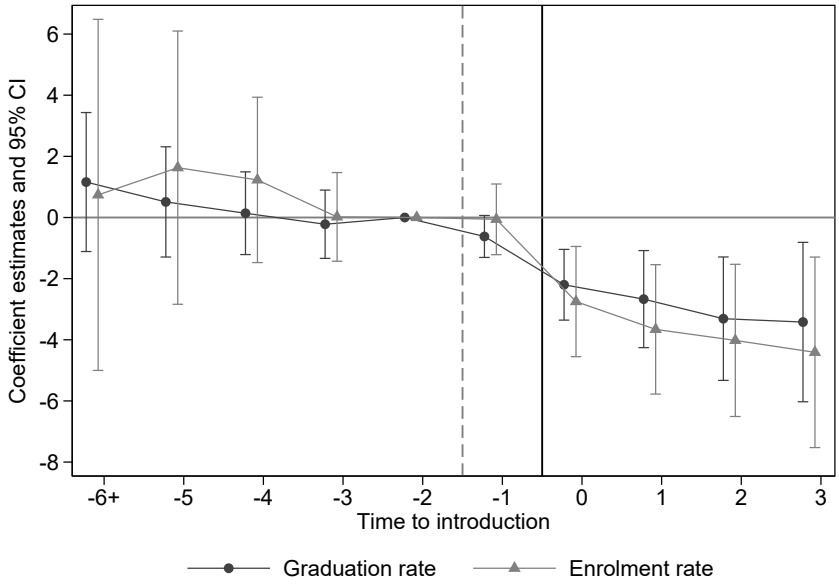
Notes: The figure presents point estimates and 95 per cent confidence intervals for the effect of tuition fees on graduation rates (black dots) and enrolment rates (grey diamonds), excluding each state in turn. All specifications are based on Equation (2), with the only difference being the exclusion of the state indicated on the horizontal axis. Abbreviations of the federal states are listed in Table A.1.

Figure A.7: Effects over time by gender

(a) Females



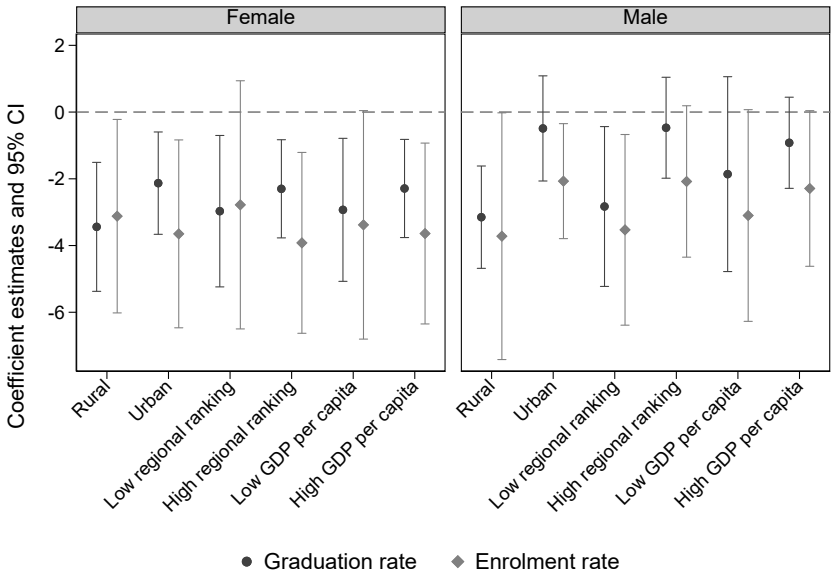
(b) Males



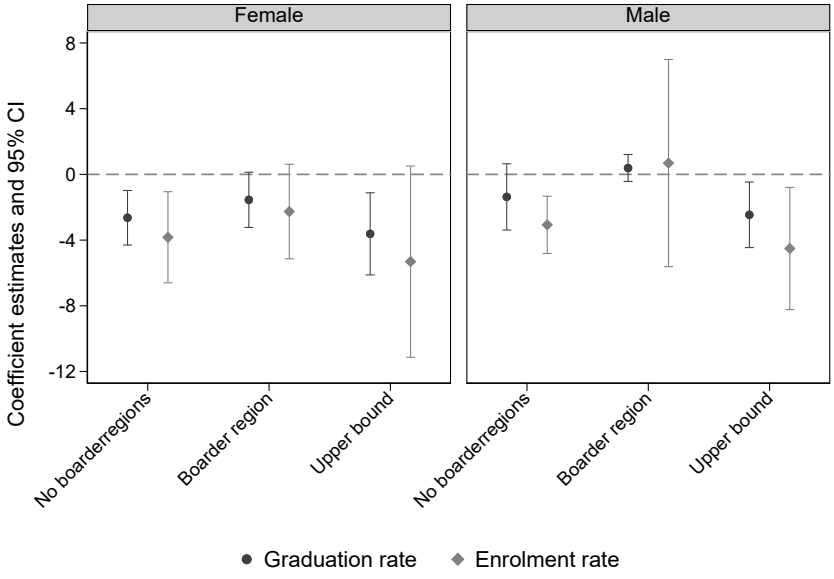
Notes: The figure displays Figure 2, separately for men and women, the point estimates and 95 per cent confidence intervals for the cohort-specific effects of tuition fees on graduation (black dots) and enrolment rates (grey diamonds), based on difference-in-differences event-study regressions.

Figure A.8: Effect heterogeneity by gender and

(a) county characteristics



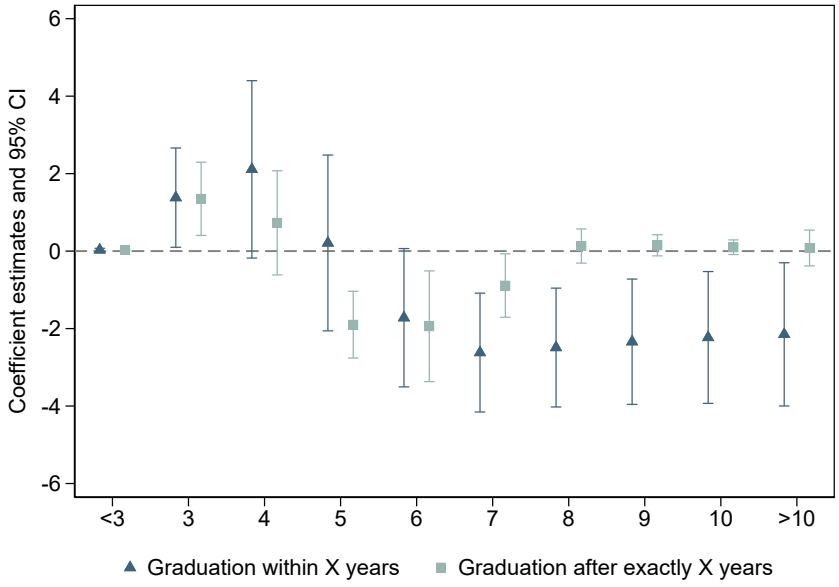
(b) mobility



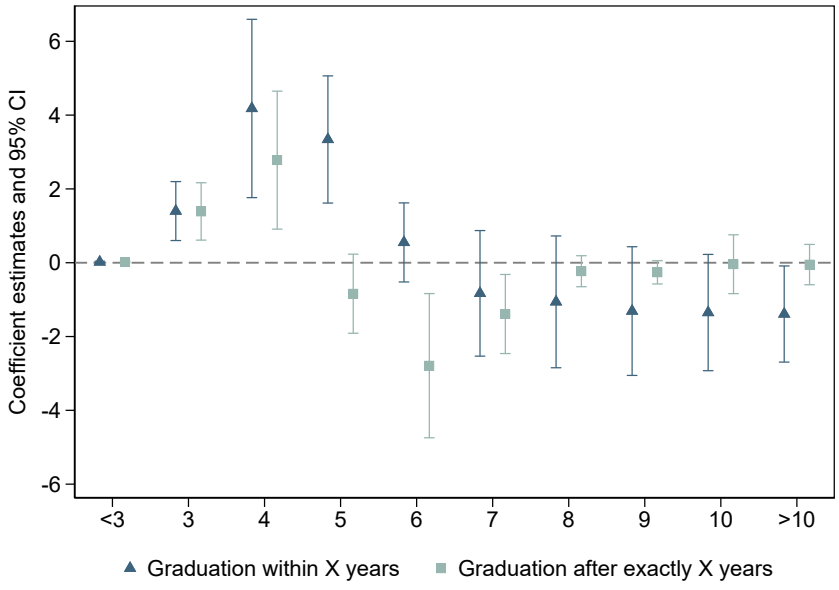
Notes: Panel A addresses effect heterogeneity and visualises the estimates from Table 6, with the key difference being that the analyses are conducted separately for men and women. Panel B focuses on student mobility and provides a gender-specific visualisation of the estimates from Table 7.

Figure A.9: The effect of tuition fees on the timing of graduation, by gender

(a) Females



(b) Males



Notes: The figure presents Figure 4, separately for women and men, point estimates and 95 per cent confidence intervals for the effect of tuition fees on university graduation within X years (dark blue triangles) and exactly after X years (light blue squares) for different study durations (X).

Table A.1: Timing of the introduction and abolition of tuition fees in the German states

	General tuition fees				Long-term fees		
	Introduction		Abolition				
State	Legislation passed	First term with general fees	Legislation passed	First term w/o general fees	First term with fees	Fees first charged after	First term w/o long-term fees
Baden-Wuerttemberg (BW)	Dec 2005	Apr 2007	Dec 2011	Apr 2012	Oct 1998	NSD + 2 years	Apr 2012
Bavaria (BY)	May 2006	Apr 2007	Apr 2013	Oct 2013	Oct 2005	NSD + 2 years	Oct 2013
Berlin (BE)	-	-	-	-	-	-	-
Brandenburg (BB)	-	-	-	-	-	-	-
Bremen (HB)	-	-	-	-	Oct 2006	7 years	Apr 2020
Hamburg (HH)	Jun 2006	Apr 2007	Sep 2011	Oct 2012	Apr 2004	NSD + 1 year	Oct 2012
Hesse (HE)	Oct 2006	Oct 2007	Jun 2008	Oct 2008	Apr 2004	NSD + 2 years	Oct 2008
Mecklenburg-Vorpommern (MV)	-	-	-	-	-	-	-
Lower Saxony (NI)	Dec 2005	Oct 2006	Dec 2013	Oct 2014	Apr 2003	NSD + 3 years	active
North Rhine-Westphalia (NW)	Mar 2006	Oct 2006	Sep 2010	Oct 2011	Apr 2004	1.5 × NSD	Oct 2011
Rhineland-Palatinate (RP)	-	-	-	-	Oct 2004	1.75 × NSD	Apr 2012
Saarland (SL)	Jul 2006	Oct 2007	Dec 2009	Apr 2010	Oct 2003	NSD + 2 years	active
Saxony (SN)	-	-	-	-	Oct 2012	NSD + 2 years	active
Saxony-Anhalt (ST)	-	-	-	-	Oct 2004	NSD + 2.5 years	Oct 2020
Schleswig-Holstein (SH)	-	-	-	-	-	-	-
Thuringia (TH)	-	-	-	-	Oct 2005	NSD + 2 years	active

Notes: The table shows the dates on which different German states introduced and abolished general tuition fees as well as regulations on long-term tuition fees. Dates in April denote the start of the summer semester and dates in October denote the start of the winter semester. NSD denotes the nominal length of study, i.e. the number of years it should take to complete a programme. States in which long-term fees are still active (as of winter term 2021) are indicated as such.
Source: Bietenbeck et al. (2023)

Table A.2: Effect heterogeneity by subject and gender

	Humanities		Social Science		STEM		Other	
	Females	Males	Females	Males	Females	Males	Females	Males
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Graduation rate								
Tuition fees	-0.65	-0.49**	-1.20	-0.90**	-0.04	0.56	-0.54***	-0.17*
	(0.51)	(0.17)	(0.71)	(0.34)	(0.52)	(0.73)	(0.16)	(0.09)
Outcome mean	10.4	3.9	12.9	10.4	11.7	18.1	3.0	1.8
Panel B: Enrolment rate								
Tuition fees	-1.22	-0.58*	-1.58*	-1.58**	-0.14	-0.34	-0.66***	-0.02
	(0.88)	(0.32)	(0.86)	(0.68)	(0.72)	(0.66)	(0.20)	(0.18)
Outcome mean	16.4	7.4	18.4	17.3	17.6	30.5	4.0	2.6
$N_{county*cohort}$	3,187	3,187	3,187	3,187	3,187	3,187	3,187	3,187
$N_{HS-Leavers}$	108,915	31,892	134,516	84,298	121,838	146,210	31,776	14,381
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table examines the heterogeneity in the effect of tuition fees on the probability of university graduation (Panel A) and university enrolment (Panel B). The columns present results for graduation and enrolment across different fields of study separately for women and men as specified in the column headers. All specifications include fixed effects for the year and county of high-school completion, as well as for the transition cohort. Robust standard errors, clustered at the federal state level, are reported in parentheses (* $p<0.1$, ** $p<0.05$, *** $p<0.01$).

10 Appendix B: Identification of ghost students

We define "ghost students" as individuals who enrol in university not with the intention of earning a degree but to access non-educational benefits. While they are not literal "ghosts," identifying them is challenging in both survey and administrative data. As a proxy for ghost students, we use the number of students who never graduate but enrol only when there are no tuition fees.[23] This group behaves in a way that aligns with the actions of rational ghost students: if the cost of university education exceeds the monetary value of the non-educational benefits, rational ghost students will cease enrolment.[24] Since this proxy inherently involves counterfactuals, it cannot be directly observed. Instead, we measure it by examining the difference between the graduation and enrolment effects, denoted as $\beta^G - \beta^E$, and in the following, we will elaborate on the assumptions that underlie this measure.

We start by recognising that there are nine distinct groups of high-school leavers based on their enrolment and graduation behaviour in both the presence and absence of tuition fees, as outlined in the table.[25]

Group	No Fees	Fees
A. Never enrol		
Enrol	0	0
Graduate	0	0
B. Ghost students		
Enrol	1	0
Graduate	0	0
C. (Enrolment-)Deterred students		
Enrol	1	0
Graduate	1	0
D. Enrolment defier		
Enrol	0	1
Graduate	0	0
E. Graduation defier		
Enrol	0	1
Graduate	0	1
F. Always dropout		
Enrol	1	1
Graduate	0	0
G. (Graduation-)Deterred students		
Enrol	1	1
Graduate	1	0
H. Graduation-induced students		
Enrol	1	1
Graduate	0	1
I. Always graduate		
Enrol	1	1
Graduate	1	1

[23] This distinguishes ghost students from regular university dropouts (Group F), who also do not graduate but enrol regardless of the tuition fee regime.

[24] This assumes that the EUR 1,000 per year in tuition fees (plus administrative semester fees) exceed the non-educational benefits of university enrolment, which seems plausible.

[25] Graduation can only occur if an individual has enrolled; hence, there are no groups that graduate without enrolling.

Y_1^E and Y_1^G represent the number of enrollees and graduates, respectively, in the presence of tuition fees, whereas Y_0^E and Y_0^G denote the corresponding numbers in the absence of tuition fees; n indicates the number of high-school leavers.

$$
\begin{aligned}
Y_1^G &= E + H + I \\
Y_0^G &= C + G + I \\
Y_1^E &= D + E + F + G + H + I \\
Y_0^E &= B + C + F + G + H + I \\
\Rightarrow \beta^G &= \frac{1}{n}(Y_1^G - Y_0^G) = \frac{1}{n}(E + H - C - G) \\
\beta^E &= \frac{1}{n}(Y_1^E - Y_0^E) = \frac{1}{n}(D + E - B - C) \\
\Rightarrow \beta^G - \beta^E &= \frac{1}{n}(B - D - G + H)
\end{aligned}
$$

The last equation shows that the difference between the graduation effect (β^G) and the enrolment effect (β^E) identifies the share of ghost students (i.e. group B) under the conditions that either $D = G = H = 0$ or $D = 0$ and $G = H$. The assumption $D = 0$ implies that there are no students who never graduate but enrol only when there are tuition fees—a reasonable assumption. The condition $G = 0$ assumes the absence of students who enrol in university regardless of the fee regime but only graduate in the absence of fees. Lastly, $H = 0$ assumes that there are no students who always enrol but graduate only when tuition fees are in place.

If $G > 0$, the difference between β^G and β^E underestimates the share of ghost students, whereas if $H > 0$, it overestimates their share. However, when $G = H$, these opposing effects cancel out, resulting again in unbiased estimation.