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Interregional Migration, Border Effects and Gender Differences

#404

Imprint

Ruhr Economic Papers

Published by

Ruhr-Universität Bochum (RUB), Department of Economics
Universitätsstr. 150, 44801 Bochum, Germany

Technische Universität Dortmund, Department of Economic and Social Sciences
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Editors

Editorial Office

Ruhr Economic Papers #404

Responsible Editor: Thomas K. Bauer

ISSN 1864-4872 (online) – ISBN 978-3-86788-459-4

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Bibliografische Informationen der Deutschen Nationalbibliothek

Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über: *http://dnb.d-nb.de* abrufbar.

http://dx.doi.org/10.4419/86788459
ISSN 1864-4872 (online)
ISBN 978-3-86788-459-4

Björn Alecke, Claudia Burgard, and Timo Mitze[1]

The Effect of Tuition Fees on Student Enrollment and Location Choice – Interregional Migration, Border Effects and Gender Differences

Abstract

This paper investigates the effects of tuition fees on the university enrollment and location decision of high school graduates in Germany. After a Federal Constitutional Court decision in 2005, 7 out of 16 German federal states introduced tuition fees for higher education. In the empirical analysis, we use the variation over time and across regions in this institutional change in order to isolate the causal effect of tuition fees on student enrollment and migration. Controlling for a range of regional- and university-specific effects, our results from Difference-in-Differences estimations show that there is generally no effect of tuition fees on internal enrollment rates. However, we find a redirecting effect on first-year students' migratory behavior as indicated by a signicant drop in the gross in-migration rates in fee-charging states. Further, our results point at a stronger migration response of male students, which, however, can mainly be attributed to a "border effect". That is, interregional migration flows of male students are redirected from fee-charging universities to those universities that are geographically close by while being located in a non-charging neighboring state. Controlling for these border effects, the relocating trend in long-distance migration of university freshmen does not show any particular gender differences.

JEL Classification: D04, I23, J16, R23

Keywords: Tuition fees; gender differences; higher education; student migration; policy evaluation; Difference-in-Differences

February 2013

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1 Introduction

Charging tuition fees for higher education continues to be a highly controversial issue. This is evidenced by the fact that, within Europe, higher education policies regarding tuition fee charging are very heterogenous and regularly changing.[1] In Germany, the Federal Constitutional Court paved the way for the introduction of tuition fees in 2005, when the decision-making autonomy was transferred to the federal state level. Shortly after this decision, 7 out of 16 German federal states introduced tuition fees. The question of raising tuition fees tourned out to be a matter of fundamental political conviction since currently, 5 out of these 7 states have again disposed tuition fees in the course of electoral changes from a conservative to a social-democratic government. In the light of this discontinuity in education policy, there are still rather few empirically well-grounded arguments dealing with the impacts of tuition fees on the general enrollment decision of German university freshmen as well as their location choice.

Particularly, the introduction of tuition fees raises the following policy questions: Do high school graduates – due to this financial burden – avoid studying in fee-raising states? Or are they, by contrast, attracted by the introduction of tuition fees as a signal for a higher quality of studies? And, if high school graduates eventually decide to take up a study, do tuition fees have an impact on their location choice?

Thus, from a national policy perspective, it may not only be essential to know whether the introduction of tuitions fees thwarts the general objective to increase the number of university freshmen in Germany. At the same time, it is important whether the implicit pricing signal associated with tuition fees can potentially be used as a policy instrument in order to redirect student flows (e.g., in favor of the East German universities as outlined in the Higher Education Pact 2020 ("Hochschulpakt 2020")).

Against the background of these research questions, this study performs a novel empirical evaluation of the enrollment and mobility effects of tuition fees in Germany. While there have been some evaluations published in the recent past, this investigation is "novel" with respect to the following three aspects: First of all, both, the effect of tuition fees on overall enrollment rates of university freshmen as well as on their locational choice, are examined, which are both interrelated and may thus be of joint relevance for policy decisions within a federal state.

Second, we evaluate the effect of tuition fees at different levels of aggregation. Particularly, when estimating the impact of tuition fees on student enrollment and mobility, we use data observed at state and university levels. Comparing different levels of aggregation helps

[1]Whether higher education should be free of charge or subject to tuition fees is handled differently by education policies in European countries. While, one the one hand, countries like Austria have recently eliminated tuition for students finishing their studies within the designated study time or practice a long-established tradition of free higher eduction such as in Scandinavia, on the other hand, the UK has increased tuition fees largely in 2012. A continuously updated database on tuition fees in Europe is published in the CESifo DICE report (the latest version can be found in the issue 1/2011), see http://www.cesifo-group.de/ifoHome/publications/journals/CESifo-DICE-Report.html.

to identify regional trends at the higher macro-level. Additionally, the disaggregate university level data allows us to control for observed and unobserved university effects, which may be an important source of heterogeneity in the sample. Further, comparing the results from the state- and university-level estimates can be seen as a crucial sensitivity check for the existence of any aggregation bias leading to incorrect policy conclusions.

Third, we put a focus on whether male and female freshmen react differently to the introduction of tuition fees. Gender differences are frequently analyzed in education-related topics and are often found to be present. With regard to gender differences in higher education, this aspect has, for instance, recently been addressed in Becker et al. (2010). Gaining insights into the existence of possibly unintended gender effects may yield further important information to judge about the pros and cons of tuition fees in the higher education system in Germany.

To do so, we use an econometric setup that exploits the variation in the regional timing of the state-level introduction of tuition fees by means of a Difference-in-Differences (DiD) estimator. At the aggregate state level, we find a statistically significant negative effect of tuition fees on total enrollment rates only for male students. Moreover, this effect is entirely driven by a net migration effect, redirecting university freshmen to states that do not charge tuition fees. We additionally estimate a dyadic migration model, which explicitly tracks individual state-to-state migration flows among each 2-tuple of states and their regime differences with respect to tuition fees.[2] The dyadic approach thus enhances the precision of the estimated impact of tuition fees on first-year students' mobility patterns compared to the analysis of the states' aggregate migratory balance. Our results here again show a redirecting effect, which is stronger for male compared to female students.

Finally, we perform the same type of analysis at the university level. This setup allows us to additionally control for observed and unobserved heterogeneity among universities as well as the relative distance between universities with different tuition fee regimes. The inclusion of geographical distance into the empirical model enables us to check if university freshmen in border regions of fee-raising and non-raising states use their location choice to react strategically to the introduction tuition fees by means of short-distance migration. Given that the total amount of the fee is rather small, it is not likely to have a strong impact on long-distance migration patterns. Universities in fee-charging states with a close-by opportunity in the form of a non-charging university would then be expected to face the biggest loss in enrollment rates.

In line with the results at the state level, the outcome of the university level model shows that there is no statistical evidence for an effect on internal enrollment rates within each state. However, universities in tuition-raising states experience a lower inflow of university freshmen from non-raising states. For male students, this effect is indeed due to a "border effect", that is, those universities are subject to a negative gross in-migration rate, which introduce tuition fees and have a non-raising university within a 50 kilometer range. Again, for female students

[2]A detailed description of the migration model for dyadic flow data is given in Appendix B.

the mobility effect is generally lower compared to male students. However, after controlling for this short-distance border effect, the long-distance migration pattern of university freshmen does not show any particular gender differences.

The remainder of the paper is organized as follows: In the next section we give a brief review of the underlying theoretical framework to evaluate the enrollment and mobility effect of tuition fees and review earlier empirical contributions in the field. Section 3 then presents, after a short sketch of the institutional setup of tuition fees in Germany, the database, some stylized facts, and outlines the econometric approach. Section 4 presents the empirical results both for aggregate state-level as well as university-level data. Section 5 finally concludes the paper with some policy implications of our findings.

2 Theory and Literature

2.1 Theoretical models of study decision and location choice

According to the human capital theory (Becker, 1964), the prospective student's decision-making process centers on a comparison of the benefits and costs of studying. Relevant factors entering into the decision making process are, besides the probability of completing the studies successfully, expected benefits, like expected labor market returns, and distinct cost factors including opportunity costs. Taken together, these aspects express the net utility from studying (see, e.g., Baier and Helbig, 2011). In these theoretical considerations, tuition fees play an ambiguous role since they may both reflect enhanced quality as well as rising costs of studying at the same time. A priori it is thus not possible to make a clear-cut prediction about which effect dominates the other at the university or state level. This brings the analysis of tuition fees inevitably to the empirical level in order to provide evidence for their impact on enrollment and mobility rates.

Linked to this general decision of taking up a study or not, is the question of where to study. Analogue to the above argumentation, student migration is profitable if the expected discounted benefits from attending a university in another state exceed the corresponding costs of migration (compare, e.g., McHugh and Morgan, 1984). The prospective student thus has to evaluate the relative utility differences between two locations rather than their absolute costs and benefits. Benefits from migrating into another state can originate from the potentially better quality of universities there or differences in the tuition fee regime under ceteris paribus conditions. Other costs associated with the migration decision comprise, for instance, housing costs, differences in living expenses as well as psychological costs of moving away from home.

Taking these aspects into account, moving from a fee-raising to a non-raising state can be profitable if the saved tuition fees exceed the housing and psychological costs. This might particularly hold for border regions of two states employing a differing fee policy there exist viable alternatives such as continuing to live at one's parental home or everyday commuting to university.

As argued above, we assume the enrollment and mobility effects of tuition fees as interrelated issues. This is supported by the fact that the introduction of tuition fees is not spatially inclusive and comprehensive and therefore affects the relative price of studying in different locations. We can thus decompose a change in the total enrollment rate at a particular university (or state) into a change in the internal enrollment rate and a migration effect (where rates are expressed in terms of the number of university freshmen relative to the age-specific population) as

$$\begin{aligned} \Delta \text{ (total enrollment/age-specific pop.)} &= \Delta \text{ (internal enrollment/age-specific pop.)} \\ &+ \Delta \text{ (net migration/age-specific pop.)}, \end{aligned}$$

where changes (Δ) in internal enrollment and net migration are expected to be unidirectional. The second term, i.e. the (net) migration or mobility effect, can further be decomposed into changes in gross in-migration and in gross out-migration as follows: Δ net migration = Δ gross in-migration − Δ gross out-migration. All these enrollment and migration measures are used as outcome variables in the empirical estimations in section 4.

Besides a general assessment of enrollment and location-choice effets of tution fees, a particular focus of this paper is to explore whether tuition fees affect the the behavioral response of male and female high school graduates asymmetrically. This can be traced back to the theoretical and empirical question whether the respective valuation of costs and returns are likely to systematically differ by gender or if they react differently to changes in costs and returns, respectively. Theoretical predictions about the direction of a gender effect depend on whether the (subjectively perceived) costs or returns are prevailing.

In general, men are often assumed to be more likely to migrate due to their higher attachment to their careers. Despite the increasing labor market participation of women, men are still able to reap more financial benefits of university education compared to women since they work more lifetime hours on average (see, e.g., Pekkarinen, 2012).

Another approach to this issue is provided by Becker et al. (2010), who present a model of supply and demand in the market for students to explain the worldwide catch-up and outrun of male graduates by female graduates in higher education. In this model, supply to higher education is determined by the average benefits and costs for students as well as their variation across individuals within each gender. Given an – exogenously specified – demand for higher education, these factors then jointly determine total enrollment (and completion) numbers by the two sexes. Consequently, any difference between males and females mainly depends on the actual distribution of benefit and cost components within the two groups. According to that, there is no clear prediction about the direction of a gender difference from theory, which has to be analysed at the empirical level.

2.2 Earlier Empirical Evidence

Many of the recent empirical studies on tuition fees in Germany are of descriptive nature rather than trying to identify causal effects.[3,4] Two exceptions, which, however, stay at a rather rough aggregate level, are studies by Hübner (2012) and by Baier and Helbig (2011) who both conduct a Difference-in-Differences (DiD) analysis. Using state-level administrative data, Hübner (2012) finds a negative effect of tuition fees on enrollment rates in fee-charging states of 2.7 percentage points which does not significantly differ by gender. He argues that this is a lower bound of the true effect, which he estimates to 4.7 percentage points based on a correction of spill-over effects to the control group. By contrast, using HIS data from 1999 to 2008, Baier and Helbig (2011) do not find a significant effect of tuition fees on the probability of studying, neither for the overall sample nor for subgroups like males and females.

The results of the remaining empirical literature are not clear cut either. While Heine et al. (2008) claim that the introduction of fees deterred graduates from studying, Baier and Helbig (2011) do not find any distortive effect. According to Heine and Quast (2011), Lörz et al. (2011), and Willich et al. (2011), gender differences seem to be present with regard to the factors influencing the decision making process to take up university studies. These studies find evidence that women's decision to study more often relies on costs of studying than men's decision, or that the expected returns from studying are valued lower among females. However, the study by Dwenger et al. (2012) finds opposing effects. Their results suggest that the probability of graduates from fee states to apply for a university in their home state drops more for males after the introduction of tuition fees. Although covering all students in one particular field of studies, the analysis is restricted to administrative data (ZVS) of medical schools, which are a very special group with regard to the allocation of university places.

Finally, rather few contributions look explicitly at mobility effects. The result of a redistributive migration effect found by Dwenger et al. (2012) is also supported by Alecke and Mitze (2012), who take a first look at interregional migration patterns of university freshmen across federal states. Their study can be seen as a point of departure for the empirical analysis in the next sections.

[3] We focus on empirical results for Germany here. International evidence is mainly based on US data. Tuckman (1970), for instance, finds that out-migration rates in the US are positively correlated with the tuition level in the resident state, which is confirmed in a study by Mixon (1992). Morgan (1983) additionally shows that favorable economic conditions of destination countries have an attracting effect on US college student migrants. Moreover, high tuition rates are found to deter non-resident students. Baryla and Dotterweich (2001) also confirm that non-resident tuition plays an important role in student migration in the US. Analysing gender differences in the determinants of interstate student migration, McHugh and Morgan (1984) find only a small difference between males and females. By contrast, the results of Faggian et al. (2007) suggest female graduates being more migratory which, according to the authors, might be explained by the assumption that females could be trying to compensate the gender bias in the labor market.

[4] The available analyses are predominantly based on a representative survey by the Higher Education Information System (HIS) comprising 5,000 high school graduates from 2006 holding a university entrance qualification.

3 Institutional Background, Data and Econometric Setup

3.1 Institutional Background and Data

In January 2005, after several decades of almost cost-free university education, the German Constitutional Court agreed with a complaint against the nationwide ban of tuition fees. It was argued that otherwise the federal states' authorization to shape education policies autonomously was constrained. Consequently, now enabled to regulate higher education charging, 7 of the 16 German federal states introduced tuition fees in the subsequent two years. In particular, the conservatively governed states of Bavaria, Baden-Wurttemberg, Hamburg, Hesse, Lower Saxony and, after a government change, also North Rhine-Westphalia announced to charge tuition fees up to a maximum amount of 500 Euro per semester. That means that – on average between 2006 and 2008 – more than 45 % out of the roughly 200 German public universities charged fees. The first cohort being aware of the upcoming fees in certain states and hence being able to decide about studying in a fee-raising or non-raising state was the one starting in the winter term 2005/2006. Recently, some federal states already abolished the fees again.[5]

For the empirical analysis, we use data on two different aggregation levels. After analyzing federal state level data in aggregated and dyadic form, we proceed on the more detailed university level. Both alternatives are based on the same source, which is administrative data of all students enrolled at a German university between 2001 and 2010.[6] This data set, the *Statistic of Students and Examinations*, is a full census of students in Germany based on reports by the examination offices and collected by the German Federal Statistical Office every semester. The data include information on the number of students, first-year students, and graduates. Information on scientific personnel are merged from another database provided by the Federal Statistical Office (2010). We combine these educational- and university-related information with information on (macro-)economic variables provided by the regional account system at the state level (State-level Account Systems, 2011) and by the Federal Employment Agency (2011).

Our outcome variables of interest are total and internal enrollment rates of university freshmen as well as their migration trends. As shown in Section 2, we can split up the effect for total enrollment rates into an internal enrollment effect and an interstate migration effect (net migration). The migration effect can be further split up into gross in-migration and gross out-migration. We then look more detailed into gross in-migration of first-year students by means of the dyadic model. The main advantage of the dyadic approach compared to the estimation of an overall migration balance for each state is that it explicitly allows to identify changes in the migratory patterns of students due to regime changes among two states, while one only observes an average effect at the overall migration balance per state. Finally, at the university level, we use four closely related variables. Like in the aggregate model, we analyze an inter-

[5]For an overview over the timing of introduction (and abolishment) see Table A.2 in the Appendix. Note that in North Rhine-Westphalia the universities themselves instead of the federal government decide about the fee introduction.

[6]At the university level, the data are only available until 2008.

nal enrollment rate and a gross in-migration rate. The latter can be split up into variables measuring the gross in-migration rate to each university from an outside fee-raising state and from an outside non-raising state. These rates are each based on the total number of high school graduates holding a university entrance qualification in fee-raising or non-raising states, respectively. A more detailed definition of the dependent variables used in our analysis can be found in Table A1 in the Appendix.

We control for a harmonized set of variables that consists of the (log of) income per capita, the (log of) unemployment rate, shares of students within the age-specific population, of graduates, of foreign students, (log of) third-party funds, a researcher-to-student ratio, and year dummies.[7] The number of observations on the aggregated state level is 160 (16 states over 10 years) and on the disaggregated state level (dyadic model) it is 2,400 (16 x 15 = 240 state tuples over 10 years).[8] In the analysis at the university level, we additionally control for the (log of) scientific personnel.

Table 1: **Distribution of universities across states in sample period**

Federal state		**Uni**	**TC**	**CAM**	**Total**
SH	Schleswig-Holstein	3	4	2	9
HH	Hamburg	3	1	2	6
LS	Lower Saxony	10	4	2	16
BR	Bremen	1	2	1	4
NRW	North Rhine-Westphalia	14	11	7	32
HS	Hesse	5	5	2	12
RP	Rhineland-Palatinate	4	7	0	11
BW	Baden-Wurttemberg	9	19	6	34
BY	Bavaria	10	15	5	30
SL	Saarland	1	1	2	4
B	Berlin	3	4	4	11
BB	Brandenburg	3	5	1	9
MV	Mecklenburg-Western Pommerania	2	3	1	6
SA	Saxony	5	5	5	15
ST	Saxony-Anhalt	2	4	1	7
TH	Thuringia	3	3	1	7
Total		78	93	42	213

Note: TC: Technical College, CAM: College of Arts or Music.

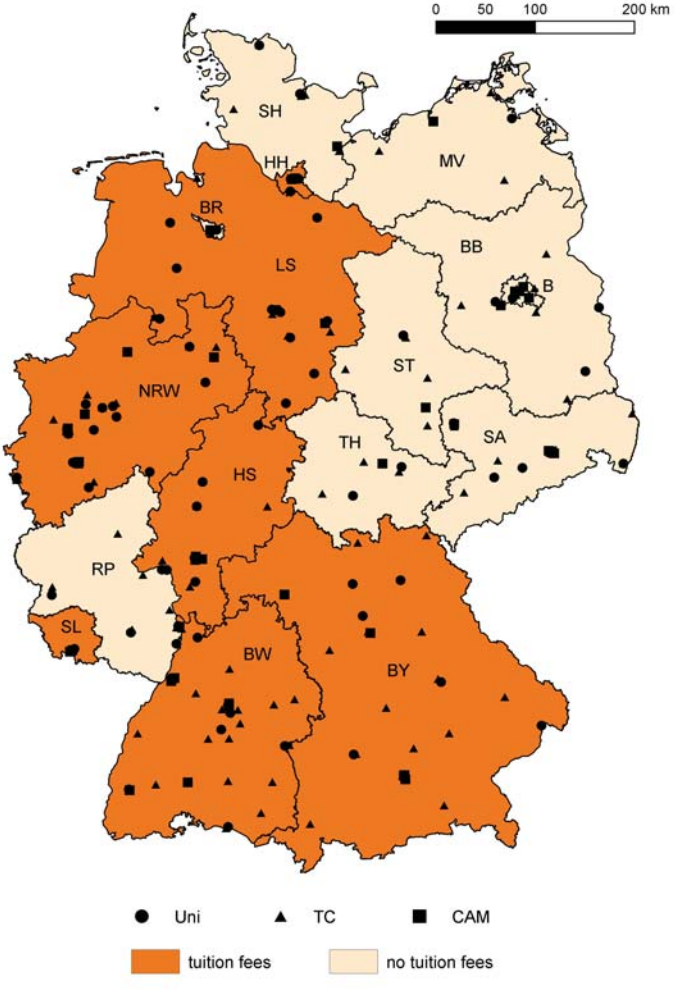
Moreover, the university-level data also allows us to further include a distance measure in our model in order to incorporate the spatial dimension of student migration. It is based on a calculated distance to the nearest fee-university or non-fee-university for non-fee-states or fee-

[7]Note that on the aggregated state level 1-year lags and in the dyadic model differences between state tuples of the control variables are used.

[8]In the empirical analysis, the actual number of observations can be lower than 2,400 if we do not observe any migratory movement between particular pairs of states in a given year.

states, respectively.[9] We further control for other reforms affecting the higher education sector that took place within our observation period.[10] We describe those reforms in the robustness section below. For the estimations on the university level, we restrict the sample to public universities since private universities are not directly affected by the introduction of tuition fees. We observe 213 universities which leaves us with 1,690 university-year observations after dropping missing values.

Figure 1: Distribution of Universities in Germany



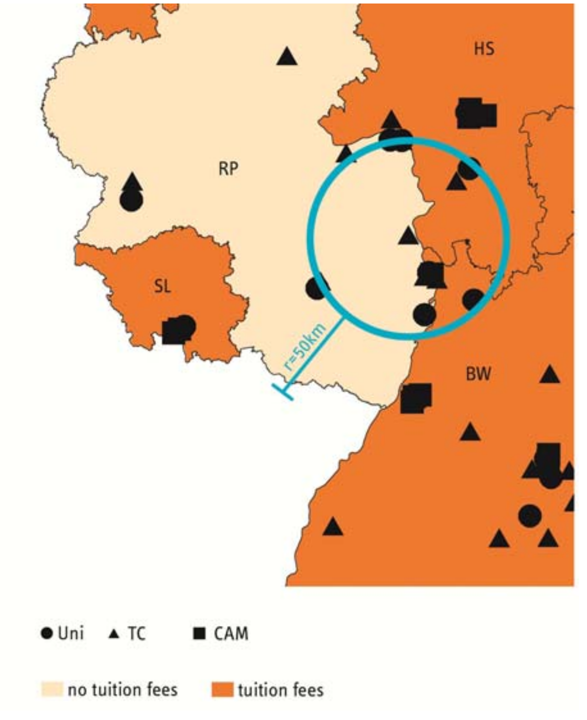
Note: TC: Technical College, CAM: College of Arts or Music.

[9]The calculation of the distances to the nearest university are based on the *Stata* ado file *geonear* which is using geodetic distances.

[10]A full list of control variables can be found in Table A.1 in the Appendix.

Public universities in Germany cover different types of universities and colleges that mainly differ by their focus which is stronger on theory at universities ("Universitäten") and more practically oriented at technical colleges (TCs, "Fachhochschulen"). Additionally, there exist colleges that offer education in specialized fields, such as colleges of arts and music (CAM, "Kunst- und Musikhochschulen"). If not explicitly stated, we refer to all types of universities and colleges as universities. The respective numbers of each type can be seen from Table 1 and the distribution of these three university types across the federal states in Germany is shown in Figure 1.

Figure 2: Example 50-kilometer-circuit



The distance measure that we use in the university-level analysis is a dummy variable that indicates whether there is a university of the same type located within a 50 kilometer circuit but in another state that employs a contrary fee policy.[11] This is illustrated in Figure 2. To give an example, this variable indicates whether in the 50 kilometer circuit of a TC in a fee-raising state there is another TC in a non-raising state. The number of universities to which this applies is listed in Table 2. The distance information in the university-level data enables us to investigate migration patterns in a more differentiated manner. In particular, we are now able to analyze "border effects", that is we reveal whether migration effects occur concentrated in border regions of two federal states employing different fee policies. Another reason for estimating both

[11] A 50 kilometer buffer was chosen as a suitable commuting distance.

on the federal state level and on the university level is the possible presence of an aggregation bias in the results from higher aggregation.

Table 2: **Number of universities with alternative within 50-km-circuit**

Tuition Fees	**Uni type**	**Number**	**Total**
Yes	Uni	9	52
Yes	TC	7	56
Yes	CAM	5	26
Total		**21**	**134**
No	Uni	5	26
No	TC	8	37
No	CAM	1	16
Total		**14**	**79**

Note: TC: Technical College, CAM: College of Arts or Music.

3.2 Econometric Setup

Our empirical analysis treats the introduction of tuition fees in Germany as an exogenous variation that is likely to affect enrollment and mobility rates of German university freshmen according to quality and cost effects. In the following, states (or universities within these states) that introduced tuition fees within the sample period, will be assigned to a treatment group, while non-raising states (universities) will serve as a comparison group. Since we are dealing with panel data, we are able to compare the evolution in outcome variables over time by means of a DiD estimation strategy. While the DiD approach is typically based on a constant pre- and post-treatment period over all observations, here we extend the original approach to a fixed effects model framework with multiple treatments that vary over states in order to account for the staggered timing of fee introduction. Our starting point for estimation is a general model of the form

$$y_{i,t} = \beta_0 + \beta_1' \mathbf{X}_{i,t} + \eta_i + \lambda_t + \tau T_{i,t} + \epsilon_{i,t}, \tag{1}$$

where $y_{i,t}$ is the outcome variable of interest (total enrollment rates, internal enrollment rates and migration trends), $\mathbf{X}_{i,t}$ is a vector of (potentially lagged) explanatory variables comprising socioeconomic and education related variables, as outlined above, and $\epsilon_{i,t}$ is a standard error term. The index i denotes the cross-sectional dimension of the data with $i = 1, \ldots, N$ and t is the time dimension with $t = 1, \ldots, T$. While η_i and λ_t define unit and time fixed effects, respectively, the regressor $T_{i,t}$ indicates the treatment which, as described above, is varying across states. β_0, β_1 and τ are coefficients to be estimated. We are particularly interested in the estimate for τ, which measures the difference in average outcomes among the treatment and comparison group according to

$$\tau = [E(Y_{i,A}|S(i) = T) - E(Y_{i,B}|S(i) = T)] - [E(Y_{i,A}|S(i) = C) - E(Y_{i,B}|S(i) = C)]. \tag{2}$$

The interpretation of τ as a causal effect depends on the identifying assumption that both the treatment and the comparison group would have experienced the same trend in the absence of the treatment. In order to minimize the risk of distortive time trends for the two groups, we include a set of time-varying regressors $\mathbf{X}_{i,t}$, which capture economic and education-related regional trends throughout the sample period. Common time trends are captured by λ_t, while time-fixed differences among units of observations are accounted for by the inclusion of unit fixed effects.

For most of the estimations, we rely on the above shown double-indexed panel data model according to equation 1 in measuring the causal effect of tuition fees on enrollment rates as well as the overall migratory balance for each state. However, when using dyadic flow data for migration, we extend the model to a triple-indexed specification for gross in-migration between state i and j at time period t. As shown in greater depth in Appendix B, the exploitation of this pairwise information allows us to set up a model with many more degrees of freedom, which increases estimation efficiency, and additionally allows us to precisely track each individual divergence in the migratory behavior among 2-tuples of treatment and comparison units. The triple-indexed specification also implies that more than one treatment effect has to be included into the regression specification.

Finally, given that we put a particular focus on exploring gender-specific effects in the outcome variables of interest, we will re-estimate all models for gender subgroups. This empirical exercise also allows us to compare the estimated coefficients for males and females in order to quantify the role of gender differences regarding size and statistical significance of the treatment effect. We do so by means of t-tests to test the null hypothesis of equal coefficients in the regression equations of male and female first-year students against the alternative of a statistically significant deviation in the behavioral responses among the sexes.

4 Empirical Results and Robustness Checks

4.1 Main Results

This section presents the empirical results from DiD estimations for the effect of tuition fees on the number of first-year students. All specifications at the different levels of data aggregation are estimated both for the overall number of first-year students and separated by gender. First, the upper part of Table 3 shows estimated effects for the aggregate model at the federal state level throughout the time period 2001 to 2010 (with a total of 160 observations). The impact of tuition fees on total enrollment rates turns out to be statistically significantly negative only for male freshmen, while the impact is estimated to be statistically insignificant for females as well as the overall specification (panel a). Decomposing this effect into an internal enrollment effect and an interstate migration effect shows that the negative effect for males is entirely attributable to a relocating net in-migration effect (panel c), while state-internal enrollment rates remain unaffected (panel b). The size of the total enrollment and the negative net in-migration effect for males is -1.6 and -1.5 %-points, respectively. While the observed gender difference in total enrollment is statistically significant according to a t-test of coefficient equality, subsequent tests in Table 3 are not able to reject the null hypothesis of a common reaction of male and female first-year students to tuition fees.

We then further split the net migration effect up into changes in the gross in-migration and gross out-migration rate, respectively. As shown in panel d and panel e of Table 3, the estimated negative net in-migration effect for males can be mainly attributed to a statistically significant drop in the gross in-migration rate into fee-charging states, while we do not find any significant impact on the gross out-migration rate. This latter asymmetry in the results can result from a changing distribution of in-migration rates after the introduction of tuition fees. A part of those high school graduates who would have migrated to a certain state for studying, will, if fees are introduced in that state, choose another state out of the non-charging ones. Average out-migration of high school graduates from fee-charging states will, however, not be affected if they primarily take the cost in the destination state into account in their migration decision.

Second, the lower part of Table 3 presents results from the dyadic migration model, which enables us to have an in-depth look into the observed male in-migration effect. In this model, we can additionally differentiate between the effect of tuition fee introduction in state i or in another state j. The results show redirecting effects as follows: On the one hand, an introduction of fees in state i causes significant out-migration of males. On the other hand, an introduction of fees in other states leads to a rising in-migration into state i of both male and female students while this effect is significantly stronger for males.

Finally, we break the analysis down to the university level to re-evaluate the above findings. Table 4 presents the estimation coefficients of interest. As described in Section 3, we now add an interaction of the treatment variable with a distance dummy indicating whether there is another university accessible within a 50 kilometer range which has a differing tuition fee regime (that is, the university is fee-charging or non-charging depending on the origin state). The results basically confirm our previous findings. Again, we observe no effect of tuition fees on internal enrollment rates (see panel a). However, we find negative effects of tuition fees on gross in-migration, that is, the results suggest that both males and females are less likely to move into fee-charging states after the introduction (panel b). There is no evidence, however, for this effect being stronger in border regions of two states with different fee policies, neither for males nor for females.

The university level analysis further allows us to identify to which kind of origin states in-migration can be attributed, i.e., whether the sending states charge fees or not. Panel c of Table 4 shows effects of the introduction of tuition fees on mobility from non-raising to fee-raising universities. We find that the migration directed from non-charging states to charging states has significantly declined after the introduction of tuition fees (panel c). In this specification, we find a statistically significant “border effect” for male students. I.e., for males, the mobility effect is driven by those universities that are located near a border to a non-raising state where an alternative university is close (within a circuit of 50 kilometers). For females, by contrast,

Table 3: **Effect of tuition fees on the number of freshmen - state level**

	All	Males	Females
Aggregate model			
a. Total enrollment rate (=b+c)			
Tuition fees	-0.004	-0.016**	0.008
	(0.008)	(0.007)	(0.010)
R^2	0.718	0.719	0.782
F-value	19.0	19.1	26.8
p-value[1]		0.060	
b. Internal enrollment rate			
Tuition fees	0.007	-0.001	0.016
	(0.007)	(0.007)	(0.010)
R^2	0.665	0.657	0.752
F-value	14.8	14.3	22.7
p-value[1]		0.190	
c. Net in-migration rate (=d+e)			
Tuition fees	-0.011	-0.015**	-0.008
	(0.007)	(0.006)	(0.010)
R^2	0.138	0.126	0.121
F-value	1.2	1.1	1.0
p-value[1]		0.527	
d. Gross in-migration rate			
Tuition fees	-0.005	-0.010**	-0.006
	(0.006)	(0.005)	(0.008)
R^2	0.688	0.706	0.694
F-value	16.5	18.0	16.9
p-value[1]		0.658	
e. Gross out-migration rate			
Tuition fees	0.005	0.005	0.002
	(0.005)	(0.004)	(0.007)
R^2	0.664	0.677	0.707
F-value	14.7	15.7	18.1
p-value[1]		0.694	
Obs.	160	160	160
Dyadic model			
Gross in-migration			
Tuition fees in state *i*	-0.017	-0.057**	0.008
	(0.018)	(0.024)	(0.021)
Tuition fees in state *j*	0.076***	0.093***	0.045**
	(0.018)	(0.024)	(0.021)
R^2	0.381	0.239	0.363
F-value	28.3	14.3	26.1
p-value[1]		0.127	
Obs.	2,400	2,391	2,398

Note: Sign. levels: * p < 0.10, ** p < 0.05, *** p < 0.01. Control variables included, compare text or full tables in Appendix. Control variables in dyadic model are defined as differences between state *i* and state *j*.
[1] from *t*-test on coefficient equality between sexes.

Table 4: **Effect of tuition fees on the number of freshmen - university level**

	All	Males	Females
a. Internal enrollment rate			
Tuition fees	0.0003	-0.0002	0.0006
	(0.0014)	(0.0007)	(0.0007)
50km*Tuition fees	-0.0001	-0.0000	-0.0001
	(0.0017)	(0.0008)	(0.0009)
R^2	0.568	0.570	0.467
p-value[1]		0.846	
b. Gross in-migration rate (=c+d)			
Tuition fees	-0.0189***	-0.0073**	-0.0115***
	(0.0054)	(0.0031)	(0.0029)
50km*Tuition fees	-0.0086	-0.0069	-0.0017
	(0.0079)	(0.0050)	(0.0034)
R^2	0.128	0.109	0.122
p-value[1]		0.414	
c. Gross in-migr. rate from outside state w/o fees			
Tuition fees	-0.0477***	-0.0190***	-0.0287***
	(0.0128)	(0.0060)	(0.0076)
50km*Tuition fees	-0.0356	-0.0275**	-0.0081
	(0.0249)	(0.0125)	(0.0132)
R^2	0.171	0.166	0.146
p-value[1]		0.301	
d. Gross in-migr. rate from outside state with fees			
Tuition fees	-0.0050	-0.0017	-0.0033
	(0.0043)	(0.0027)	(0.0022)
50km*Tuition fees	0.0044	0.0030	0.0013
	(0.0062)	(0.0041)	(0.0031)
R^2	0.069	0.049	0.078
p-value[1]		0.871	
Obs.	1,689	1,689	1,689

Note: Sign. levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Control variables included, compare text or full tables in Appendix.
[1]from *t*-test on coefficient equality between sexes.

this "border effect" cannot be observed. However, after controlling for this border effect, female and male students do not respond significantly different anymore in terms of their long-distance migration behavior. Finally, panel d indicates that freshmen from charging states do not significantly change their migratory behavior, which is independent of the distance to a non-raising university. Migration from fee-raising universities to another fee-raising state does not change significantly, neither for males nor for females.

Thus, we do not find evidence for any impact of tuition fees on internal enrollment rates, neither at the state nor at the university level. However, we find a redistributing migration effect of tuition fees, which is stronger for male students compared to female students. If we look more carefully at the kind of migratory behavior, we see that most of the effect for males is driven by "border universities". These results imply that there is some evidence that tuition fees do not have a common overall effect but instead affect certain groups of students who have the favorable choice to enroll at a fee-raising or non-raising university without moving far (or at all). Changes in enrollment behavior which mainly seem to take place at borders of charging and non-charging states, are probably due to the absence of additional costs for moving to the other state. After controlling for that "border effect", gender differences almost disappear completely, which is confirmed by the results of the t-tests on coefficient equality between the two groups.

We still have to address the question why only male freshmen tend to show such a borderline migration behavior. One approach to explain the male "border effect" is rooted in differences in the chosen fields of study that are widely known to be present among male and female students. For instance, males may more often choose general fields of study (such as engineering, computer science, mathematics, etc.), which are offered by more universities, giving them more possibilities to move within a rather narrow geographical range. However, when we include the composition of fields of study by gender into our estimation model as an explicit control factor, the empirical results are not affected. Thus, we do not find evidence for this type of argumentation. Still, males who migrate to non-charging universities will probably expect a higher net utility from studying there compared to studying in a fee-raising state. A reason for that could be that, compared to females, they do not expect large changes in returns due to tuition fees. Further, our results are in line with a previous study by Dwenger et al. (2012) who find that male high school graduates planning to study in the medical field are more likely to migrate from fee-raising states to other states after the introduction of tuition fees.

4.2 Robustness Checks

In the following, we will discuss the validity and robustness of our results. One critical issue raised by Baier and Helbig (2011) is that the number of so-called "pseudo students" is expected to drop in tuition-charging states, which could lead to a slight overestimation of the effect. Those students are persons who are enrolled at a university not intending to study but just to take advantage of student privileges like a local public transport ticket by paying a relative small contribution. This could, if significantly at all, only affect internal enrollment rates and is unlikely to influence mobility rates.

Another critical remark may be associated with our empirical identification strategy. The DiD approach rests on certain assumptions, such as the existence of common trends, whose validity cannot explicitly be tested. However, we argue that this assumption is likely to hold in our setting. A violation of the common trends assumption could, for instance, be induced by economic shocks or policy changes by which the treatment and control group are influenced differently. In our analysis, this might occur if, e.g., one of the following policies during the time period under investigation affected the number of first-year students differently in fee-raising and non-raising states. First, the Higher Education Pact 2020 is explicitly aiming at increasing the number of university places in order to manage growing numbers of first-year students. Second, winner universities of the Excellence Initiative ("Exzellenzinitiative") are likely to attract students. Both programs started during our observation period, that is in 2007 and 2006, respectively. We can rule out potential bias arising from those programs by showing that rerunning the regressions, while including indicator variables for the introduction of the Higher Education Pact 2020 and for being a winner university or not leaves our results unaffected.

Third, German universities have faced a financial reform towards a performance-based funding, which has been started in the 1990's and has been introduced in a staggered way across federal states (compare Burgard and Grave, 2013). We remove potential influences from this reform by including a variable capturing the share of university financing that is linked to the number of students. Possibly increasing numbers of students are naturally related to the number of freshmen. Fourth, during the time period under analysis, the Bologna reform has taken place. We counter that source of bias by controlling for the share of freshmen who start studying in a "new degree", i.e., a Bachelor or Master degree. Finally, some German states shortened the number of compulsory schooling years until receiving a degree qualifying for studying at university from 13 to 12 years. During the observed time span, this was the case in Mecklenburg-Vorpommern in 2008, and in Saxony Anhalt in 2007. We account for that by introducing corresponding dummy variables.

Another problem with DiD estimation can arise in form of the so-called Ashenfelter's dip (Ashenfelter, 1978) which describes the phenomenon that members of the treatment group may react to the announcement of the treatment. That would distort the measured treatment effect by the extent of the premature effect. In order to exclude this problem, we conduct sensitivity checks using an alternative treatment variable that is based on the announcement of tuition fees instead of the actual introduction. Our results remain basically unchanged.

Finally, by performing the analysis at different levels of aggregation, our findings turn out to be robust with regard to aggregation bias.

5 Conclusion

The pros and cons of charging tuition fees are subject to intense public debate. In Germany, a Federal Constitutional Court decision in 2005 empowered federal states to choose their preferred tuition fee regime. As a result, 7 out of the 16 federal states decided to introduce tuition fees in 2006 and 2007. Using this exogenous institutional shock, which results in regional and temporal variation in tuition fee regimes in Germany, this paper investigates the effects of tuition fees at German universities on the enrollment and migration behavior of first-year students. On the one hand, tuition fees constitute higher direct costs of studying while on the other hand, they might induce a higher quality of studies. Therefore, the direction of any impact of fees on high school graduates' decision is a priori unclear and remains an empirical matter.

In our empirical analysis, we use data at the federal state level and the university level data and employ a DiD approach. At the aggregated state level, we observe a statistically significant negative effect of tuition fees on total enrollment rates only for male students. Splitting this effect up into internal enrollment and interstate migration reveals that it is completely attributable to a drop in gross in-migration rates into fee-charging states among males. This result is confirmed by estimating a dyadic model, which treats each migration flow among two states as an individual observation. The university level framework finally enables us to refine the analysis and to identify “border effects”, that is we examine whether migratory effects are concentrated at borders of two federal states that employ diverging tuition fee policies. While internal enrollment rates remain unaffected, gross in-migration from non-charging into charging states is negatively affected. The latter effect turns out to be driven by short-distance migration of first-year male students across state borders. Controlling for these “border effects”, gender differences in the relocating trend in long-distance migration of university freshmen disappear.

Concluding from our results, we do not find evidence for any impact of tuition fees on internal enrollment rates but a redistributing migration effect of tuition fees, which is stronger for male students compared to female students. When examining the migratory behavior in more detail, we see that most of the effect for males is driven by short-distance cross-border migration. These findings suggest that tuition fees do not have a common overall effect but instead affect particularly those who live near both, a fee-raising and non-raising university, i.e., high school graduates do not need to move if they want to avoid to pay tuition fees.

Thus, our analysis does not confirm the standard argument against tuition fees, namely that higher costs operated as a general deterrence for taking up a study at all. We also do not observe large (but still some) migratory effects beyond a 50 kilometer distance, which can be commuted without bearing relocation costs. The specific “border effect” found in our analysis is likely a result of the relative low overall amount of tuition fees in Germany, which is roughly 500 Euro per term. Although tuition fees have already been abolished in many states of Germany, there is still a need for larger investments in tertiary education. The latter are a crucial component in the higher education system in order to improve the universities' funding base and to ensure the basic conditions to provide high-quality education (compare Chapman and Sinning, 2013). Tuition fees can help to realize such essential goals. An alternative to the traditional upfront payment of fees are income contingent loans as applied in Australia, England and New Zealand. Such a funding system equalizes the access to university education as claimed by opponents of tuition fees.

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A Appendix - Tables

Table A3.1: **Definition of Variables**

Variable	Definition	Source
a. Dependent variables		
a1. State level - aggregated model		
Total enrollment	Share of first-year students (adjusted)[1] within age-specific population	Federal Statistical Office (2011c)
Mobility	In-migration minus out-migration of first-year students	Federal Statistical Office (2011c)
Internal enrollment	Share of first-year students (adjusted) minus migration balance within age-specific population	Federal Statistical Office (2011c)
Net in-migration rate	In-migration minus out-migration of first-year students relative to age-specific population	Federal Statistical Office (2011c)
Gross in-migration rate	In-migration of first-year students within age-specific population	Federal Statistical Office (2011c)
Gross out-migration rate	Out-migration of first-year students within age-specific population	Federal Statistical Office (2011c)
a2. State level - dyadic model		
Gross in-migration of freshmen	Gross in-migration of first-year students between state i and j	Federal Statistical Office (2011c)
a3. University level		
Internal enrollment rate	Share of first-year students in state j with university entrance qualification acquired in the same state	Statistic of Students and Examinations
Gross in-migration rate	Share of first-year students in state j with university entrance qualification acquired in another state	Statistic of Students and Examinations
Gross in-migration rate from outside state w/o fees	Share of first-year students in state j with university entrance qualification acquired in an outside non-charging state	Statistic of Students and Examinations
Gross in-migration rate from outside state with fees	Share of first-year students in state j with university entrance qualification acquired in an outside fee-charging state	Statistic of Students and Examinations
b. Explanatory variables		
Tuition fees	0/1-variable; 1 if the reform is *introduced* in state j at time t	based on Table A.2
Tuition fees (a)	0/1-variable; 1 if the reform is *announced* in state j at time t	based on Table A.2
b1. State level[2]		
Log(Income p.c.)	Logarithm of real GDP per capita in Euro	State-level Account Systems (2011)
Log(Unemployment rate)	Logarithm of unemployment rate in %	National Employment Agency (2011)
Share of students	Share of students per 1,000 inhabitants	Federal Statistical Office (2011c)
Graduation rate	Logarithm of graduation rate in %	Federal Statistical Office (2011b)
Share of foreign freshmen	Logarithm of foreign students in %	Federal Statistical Office (2011c)
Log(Third-party funds)	Logarithm of third-party funds per researcher in 1,000 Euro	Federal Statistical Office (2011a)
Researcher-to-student ratio	Number of researchers per 100 students	Federal Statistical Office (2011b)
b2. ...additionally in dyadic model		
Log(No. of freshmen in state i)	Logarithm of number of freshmen in destination state (i)	Federal Statistical Office (2011c)
Log(No. of freshmen from state j)	Logarithm of number of freshmen in home state (j)	Federal Statistical Office (2011c)
Four region-time-dummies	Dummies for each year accounting for migration within East and West Germany each, and between East and West Germany, respectively	
b3. University level		
Graduation rate	Number of graduates relative to 4-year-lagged number of students	Statistic of Students and Examinations
Log(Scient. pers.)	Logarithm of scientific personnel	Statistic of Students and Examinations
Students/research ass.	Number of students per research assistant	Statistic of Students and Examinations
Log(Third-party funds)	Log of third-party funds in current year in Euro	Federal Statistical Office (2011a)
Share foreign fy stud.	Share of foreign first-year students	Statistic of Students and Examinations
Log(Income p.c.)	See above	Statistic of Students and Examinations
Log(Unemployment rate)	See above	Statistic of Students and Examinations
Share of new degrees	Share of first-year students who started studying in a Bachelor or Master degree	Statistic of Students and Examinations
Reform in school yrs. to 12 y.	0/1-variable; 1 if there was a reform in school years from 13 to 12 years in state j at time t	Conference of the Ministers of Education and Cultural Affairs (2012)
Reform in school yrs. to 13 y.	0/1-variable; 1 if there was a reform in school years from 12 to 13 years in state j at time t	Conference of the Ministers of Education and Cultural Affairs (2012)
Funding reform	Share of indicator-based funding regarding students	

Note: [1]Adjusted by number of foreign first-year students.
[2]Note that on the aggregated state level 1-year lags and on the disaggregated state level differences between state tuples of the listed variables are used.

Table A.2: **Introduction and abolishment of tuition fees in Germany**

State	**Announcement**[1]	**Introduction**	**Announcement**[2]	**Abolishment**
Baden-Wurttemberg	December 2005	Summer 2007	July 2011	Summer 2012
Bavaria	May 2006	Summer 2007		
Hamburg	June 2006	Summer 2007	September 2011	Winter 2012
Hesse	October 2006	Winter 2007	July 2008	Winter 2008
Lower Saxony	December 2005	Winter 2006		
North Rhine-Westphalia	March 2006	Winter 2006	February 2011	Winter 2011
Saarland	July 2006	Winter 2007	February 2010	Summer 2010

Note: [1] of introduction. [2] of abolishment.

Table A.3: **Aggregate model: Gross in-migration rate**

	All	**Males**	**Females**
Tuition fees	-0.004	-0.016**	0.008
	(0.008)	(0.007)	(0.010)
log(Income p.c.)	0.178	0.133	0.204
	(0.134)	(0.127)	(0.184)
log(Unemployment rate)	0.029	0.016	0.052
	(0.037)	(0.036)	(0.052)
Share of students in pop.	-0.000	0.001	-0.004
	(0.002)	(0.002)	(0.003)
Graduation rate	-0.001*	-0.001	-0.002
	(0.001)	(0.001)	(0.001)
Share of foreign students	-0.565**	-0.572**	-0.288
	(0.242)	(0.230)	(0.333)
log(Third-party funds)	-0.031	-0.027	-0.037
	(0.024)	(0.023)	(0.033)
log(Student-to-researcher ratio)	0.031	-0.011	0.092
	(0.048)	(0.046)	(0.066)
Constant	0.592**	0.630**	0.485
	(0.259)	(0.246)	(0.356)
Year effects	Yes	Yes	Yes
R^2	0.718	0.719	0.782
F-value	19.0	19.1	26.8
Obs.	160	160	160

Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.4: **Aggregate model: Gross out-migration rate**

	All	**Males**	**Females**
Tuition fees	0.007	-0.001	0.016
	(0.007)	(0.007)	(0.010)
log(Income p.c.)	0.162	0.178	0.198
	(0.132)	(0.130)	(0.183)
log(Unemployment rate)	0.022	0.017	0.023
	(0.037)	(0.036)	(0.051)
Share of students in pop.	-0.001	-0.000	-0.004
	(0.002)	(0.002)	(0.003)
Graduation rate	-0.002***	-0.002**	-0.003**
	(0.001)	(0.001)	(0.001)
Share of foreign students	-0.308	-0.405*	-0.158
	(0.238)	(0.234)	(0.331)
log(Third-party funds)	-0.073***	-0.053**	-0.093***
	(0.024)	(0.024)	(0.033)
log(Student-to-researcher ratio)	0.048	0.022	0.082
	(0.047)	(0.047)	(0.066)
Constant	0.666***	0.691***	0.743**
	(0.255)	(0.251)	(0.354)
Year effects	Yes	Yes	Yes
R^2	0.665	0.657	0.752
F-value	14.8	14.3	22.7
Obs.	160	160	160

Significance levels: * p < 0.10, ** p < 0.05, *** p < 0.01.

Table A.5: **Aggregate model: Net in-migration rate**

	All	**Males**	**Females**
Tuition fees	-0.011	-0.015**	-0.008
	(0.007)	(0.006)	(0.010)
log(Income p.c.)	0.016	-0.045	0.005
	(0.122)	(0.109)	(0.170)
log(Unemployment rate)	0.008	-0.001	0.029
	(0.034)	(0.030)	(0.048)
Share of students in pop.	0.001	0.001	-0.000
	(0.002)	(0.002)	(0.002)
Graduation rate	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)
Share of foreign students	-0.257	-0.168	-0.130
	(0.220)	(0.197)	(0.308)
log(Third-party funds)	0.041*	0.026	0.056*
	(0.022)	(0.020)	(0.031)
log(Student-to-researcher ratio)	-0.017	-0.033	0.010
	(0.044)	(0.039)	(0.061)
Constant	-0.075	-0.062	-0.258
	(0.235)	(0.211)	(0.329)
Year effects	Yes	Yes	Yes
R^2	0.138	0.126	0.121
F-value	1.2	1.1	1.0
Obs.	160	160	160

Significance levels: * p < 0.10, ** p < 0.05, *** p < 0.01.

Table A.6: **Aggregate model: Internal enrollment rate**

	All	**Males**	**Females**
Tuition fees	-0.005	-0.010**	-0.006
	(0.006)	(0.005)	(0.008)
log(Income p.c.)	0.136	0.086	0.157
	(0.098)	(0.084)	(0.144)
log(Unemployment rate)	0.029	0.010	0.053
	(0.027)	(0.024)	(0.040)
Share of students in pop.	-0.001	-0.001	-0.003
	(0.001)	(0.001)	(0.002)
Graduation rate	-0.001	-0.000	-0.000
	(0.001)	(0.001)	(0.001)
Share of foreign students	-0.157	-0.093	-0.008
	(0.177)	(0.152)	(0.260)
log(Third-party funds)	0.034*	0.026*	0.041
	(0.018)	(0.015)	(0.026)
log(Student-to-researcher ratio)	0.032	0.014	0.063
	(0.035)	(0.030)	(0.052)
Constant	0.102	0.131	0.005
	(0.190)	(0.163)	(0.278)
Year effects	Yes	Yes	Yes
R^2	0.688	0.706	0.694
F-value	16.5	18.0	16.9
Obs.	160	160	160

Significance levels: * p < 0.10, ** p < 0.05, *** p < 0.01.

Table A.7: **Aggregate model: Net in-migration rate**

	All	**Males**	**Females**
Tuition fees	0.005	0.005	0.002
	(0.005)	(0.004)	(0.007)
log(Income p.c.)	0.120	0.131*	0.152
	(0.082)	(0.074)	(0.116)
log(Unemployment rate)	0.022	0.011	0.024
	(0.023)	(0.021)	(0.032)
Share of students in pop.	-0.002	-0.002	-0.003*
	(0.001)	(0.001)	(0.002)
Graduation rate	-0.001**	-0.001**	-0.002**
	(0.001)	(0.000)	(0.001)
Share of foreign students	0.099	0.075	0.123
	(0.147)	(0.134)	(0.209)
log(Third-party funds)	-0.007	-0.000	-0.015
	(0.015)	(0.013)	(0.021)
log(Student-to-researcher ratio)	0.049*	0.047*	0.053
	(0.029)	(0.027)	(0.042)
Constant	0.177	0.193	0.262
	(0.158)	(0.143)	(0.223)
Year effects	Yes	Yes	Yes
R^2	0.664	0.677	0.707
F-value	14.7	15.7	18.1
Obs.	160	160	160

Significance levels: * p < 0.10, ** p < 0.05, *** p < 0.01.

Table A.8: **Dyadic model: Gross in-migration**

Tuition fees in state i	-0.017	-0.057**	0.008
	(0.018)	(0.024)	(0.021)
Tuition fees in state j	0.076***	0.093***	0.045**
	(0.018)	(0.024)	(0.021)
log(Income p.c.)	0.877***	0.749***	1.032***
	(0.198)	(0.267)	(0.231)
log(Unemployment rate)	-0.064	-0.227**	0.104
	(0.071)	(0.097)	(0.084)
log(Third-party funds)	0.056	0.055	0.070
	(0.046)	(0.062)	(0.054)
Student-to-researcher ratio	-0.076	-0.117	0.021
	(0.098)	(0.133)	(0.115)
Share of students in pop.	0.134	-0.029	0.214*
	(0.102)	(0.138)	(0.119)
Share of foreign students	0.092*	0.101	0.075
	(0.049)	(0.066)	(0.057)
Graduation rate	-0.004	-0.090*	0.063
	(0.039)	(0.052)	(0.046)
log(No. of freshmen from state i)	0.804***		
	(0.073)		
log(No. of male freshmen from state i)		0.657***	
		(0.086)	
log(No. of female freshmen from state i)			0.802***
			(0.064)
Constant	-11.977***	-10.323***	-11.266***
	(0.691)	(0.759)	(0.563)
R^2	0.381	0.239	0.363
F-value	28.3	14.3	26.1
p-value[1]		0.127	
Obs.	2,400	2,391	2,398

Note: Sign. levels: * p < 0.10, ** p < 0.05, *** p < 0.01.
[1]: p-value from t-test on coefficient equality between sexes.
Control variables are defined as differences between state i and state j. For computational details see Appendix B.

Table A.9: **University-level model specifications**

	a. Internal enrollm.			**b. Gross in-migr. (=c+d)**			**c. From outside w/o fees**			**d. From outside with fees**		
	All	**Males**	**Females**	**All**	**Males**	**Females**	**All**	**Males**	**Females**	**All**	**Males**	**Females**
Tuition fees	0.000	-0.000	0.001	-0.019***	-0.007**	-0.012***	-0.048***	-0.019***	-0.029***	-0.005	-0.002	-0.003
	(0.001)	(0.001)	(0.001)	(0.005)	(0.003)	(0.003)	(0.013)	(0.006)	(0.008)	(0.004)	(0.003)	(0.002)
50km*Tuition fees	-0.000	-0.000	-0.000	-0.009	-0.007	-0.002	-0.036	-0.027**	-0.008	0.004	0.003	0.001
	(0.002)	(0.001)	(0.001)	(0.008)	(0.005)	(0.003)	(0.025)	(0.012)	(0.013)	(0.006)	(0.004)	(0.003)
Graduation rate	0.008	-0.002	0.010	0.120*	0.051	0.070**	0.225	0.104	0.120	0.070	0.025	0.045**
	(0.015)	(0.009)	(0.008)	(0.066)	(0.037)	(0.032)	(0.141)	(0.075)	(0.075)	(0.045)	(0.025)	(0.022)
Research ass./students	-0.044*	-0.016	-0.028**	-0.401***	-0.186***	-0.215***	-1.022***	-0.477***	-0.544***	-0.103**	-0.046**	-0.057**
	(0.023)	(0.012)	(0.012)	(0.082)	(0.040)	(0.046)	(0.215)	(0.103)	(0.118)	(0.041)	(0.022)	(0.023)
Share foreign fy stud.	-0.020***	-0.010***	-0.010***	0.014	0.010	0.004	0.114***	0.066***	0.048**	-0.034***	-0.017***	-0.017***
	(0.006)	(0.004)	(0.003)	(0.015)	(0.007)	(0.008)	(0.036)	(0.018)	(0.020)	(0.010)	(0.005)	(0.005)
Share of new degrees	-0.003	-0.002	-0.001	-0.013	-0.007*	-0.006	-0.029*	-0.018**	-0.010	-0.006	-0.002	-0.004
	(0.002)	(0.001)	(0.001)	(0.008)	(0.004)	(0.004)	(0.017)	(0.009)	(0.009)	(0.006)	(0.003)	(0.003)
log(Scient. pers.)	0.016***	0.007***	0.009***	0.066***	0.032***	0.034***	0.141***	0.067***	0.074***	0.029**	0.014**	0.015**
	(0.005)	(0.002)	(0.003)	(0.018)	(0.008)	(0.011)	(0.039)	(0.017)	(0.024)	(0.012)	(0.006)	(0.006)
log(Third p.f./research ass.)	0.001	0.000	0.000	0.003	0.002	0.001	0.009*	0.005*	0.005*	-0.000	0.000	-0.001
	(0.001)	(0.000)	(0.000)	(0.003)	(0.001)	(0.001)	(0.005)	(0.003)	(0.003)	(0.002)	(0.001)	(0.001)
Funding reform	-0.000	-0.000*	-0.000	-0.000	-0.000	-0.000	-0.001*	-0.000	-0.000**	0.000	0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Reform in school yrs. to 12	-0.011**	-0.005**	-0.006**	-0.039***	-0.018**	-0.021***	-0.112***	-0.059***	-0.053***	-0.004	0.001	-0.005
	(0.005)	(0.003)	(0.003)	(0.011)	(0.007)	(0.006)	(0.025)	(0.016)	(0.014)	(0.007)	(0.004)	(0.003)
Reform in school yrs. to 13	0.160***	0.111***	0.050***	0.003	0.000	0.003	0.006	0.003	0.003	0.002	-0.001	0.002
	(0.033)	(0.024)	(0.009)	(0.009)	(0.004)	(0.006)	(0.026)	(0.011)	(0.016)	(0.005)	(0.003)	(0.003)
Log(Income p.c.)	-0.000	0.002	-0.002	0.356***	0.143**	0.212***	1.250***	0.551***	0.699***	-0.075	-0.053	-0.022
	(0.031)	(0.019)	(0.014)	(0.116)	(0.060)	(0.064)	(0.271)	(0.129)	(0.159)	(0.078)	(0.043)	(0.042)
Log(Unemployment rate)	0.001	-0.002	0.003	0.017	-0.008	0.024*	0.033	-0.020	0.053	0.009	-0.002	0.010
	(0.005)	(0.003)	(0.003)	(0.029)	(0.016)	(0.014)	(0.061)	(0.033)	(0.033)	(0.021)	(0.013)	(0.009)
R^2	0.568	0.570	0.467	0.128	0.109	0.122	0.171	0.166	0.146	0.069	0.049	0.078
Obs.	1,689	1,689	1,689	1,689	1,689	1,689	1,689	1,689	1,689	1,689	1,689	1,689

Note: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B Appendix - Dyadic specification

Eq. 1 in the text describes our basic DiD estimation approach in a panel data context in order to quantify the impact of tuition fees on the (total and internal) enrollment as well as mobility rate of university freshmen. This approach is surely suitable for the analysis of aggregate rates, when the cross-sectional dimension is made of regional entities or universities. However, in the case of student mobility there may be a loss in estimation precision associated with the use of aggregate information. This is due to the fact that a region's aggregate migration balance is defined as the total number of in- or outflows from or to all other states. In the case of our research question this aggregation may be problematic, since it dilutes the observable impact of tuition fee introduction given that the aggregate migration balance for each state is composed of a mix of flows from introducing and non-charging states in each point of time.

To overcome this shortcoming, we have also estimated the impact of tuition fees on regional gross in-migration rates based on a pairwise migratory patterns of university freshman among each 2-tuple of German states. The basic structure of this dyadic model shall be outlined in this Appendix. The aim of the dyadic approach is to make use of the full set of information available for the number of student migration flows among a set of origin-destination pairs for each point in time. We follow LeSage and Pace (2008) and define a migration matrix $\mathbf{M}$ to be an $n \times n$ square matrix of interregional migration flows in a closed system from each of the n origin regions to each of the n destination regions, where the columns represent different origins (o_i) and the rows represent destinations (d_j) with $i, j = 1, \ldots, N$ as

$$\mathbf{M} = \begin{pmatrix} o_1 \to d_1 & o_2 \to d_1 & \ldots & o_n \to d_1 \\ o_1 \to d_2 & o_2 \to d_2 & \ldots & o_n \to d_2 \\ \vdots & \vdots & \ddots & \vdots \\ o_1 \to d_n & o_2 \to d_n & \ldots & o_n \to d_n \end{pmatrix}. \quad (3)$$

Since we do not observe information on intra-regional migration flows (that is main diagonal elements of M with $o_1 \to d_1$ and so on) our migration matrix has the dimension $[(n) \times (n-1)]$. Then, taking an origin-centric perspective, we can then construct a stacked vector $m = vec(\mathbf{M})$, whose first $n-1$ elements reflect flows from origin 1 to all $n-1$ destinations (excluding intraregional flows). Since we use migration data among 16 German federal states, this results in $16 \times 15 = 240$ observations for each year. Using data for the time period 2001 to 2010, our panel data framework covers a total number of observations as $240 \times 10 = 2400$.

For the empirical estimation we use a log-linear specification, where the dependent variable is the gross in-migration rate defined as gross in-migration flows $inm_{ij,t}$ to region i from j at time period t as share of the total number of university freshmen in region i. $\widetilde{\mathbf{X}}_{ij,t-1}$ is the vector of explanatory variables, which are restricted to enter as inter–regional differences so that these variables have a triple-indexed form (ij, t) as well.[12] Formally, $\tilde{x}_{ij,t}$ for any variable

[12] The only exclusion are university freshmen in region j at time t, which enter as a double-indexed variable to control for size effects in the destination regions. Remember that the number of university freshmen in region i is already used to construct the dependent variable, so it does not enter here again.

$x_{ij,t}$ is defined as $\tilde{x}_{ij,t} = (x_{i,t} - x_{j,t})$. As also done for the aggregate specifications, variables in $\widetilde{\mathbf{X}}_{ij,t-1}$ enter as one period lags in order to rule out feedback effects from the dependent variables. The full model takes the form

$$inm_{ij,t} \quad = \quad \beta_0 + \beta_1' \widetilde{\mathbf{X}}_{ij,t-1} + \eta_{ij} + \lambda_t + \tau_1 T^1_{i,t} + \tau_2 T^2_{j,t} + \epsilon_{ij,t} \tag{4}$$

where η_{ij} denote unit-fixed effects for each pair of migration flows, λ_t are time-fixed effects for each period t and $\epsilon_{ij,t}$ is the model's error term. $\eta_{i,j}$ and $\epsilon_{i,j,t}$ are assumed to be independent over the cross-sectional dimension with $\epsilon_{i,j,t}$ being distributed as $N(0, \sigma^2_\epsilon)$. Finally, different from the specification in eq. 1, we now include two DiD-terms $T^1_{i,t}$ and $T^2_{i,t}$, which allow for the fact that the introduction of tuition fees in region i and region j may not have a symmetric adverse effect on the in migration rate of state i. β_0, β_1', τ_1 and τ_2 are coefficients to be estimated. Since the model is estimated in a log-linear specification, the estimated coefficients can be interpreted as elasticities. In the case of the DiD-term the coefficients τ_1, τ_1 quantify the percentage change in the state's gross in-migration rate for a discrete change (from 0 to 1) in the tuition fee regime of state i and j, respectively.