Educational Choices in Germany

Empirical Essays in the Economics of Education

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Thesis

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Contents

General Introduction

Motivation

The factors that determine a person's educational choices at different stages of his or her life and the output of the choices have been of much interest to academics and politicians. As education has often been shown to be a key determinant for the well-being and growth of a society, politicians continually aim to increase the level of education within their country. For this task the political planner needs information on how individuals decide about their final educational level and the paths that lead to the final degree. For the individuals on the other side, to make informed decisions the outcome of their educational choices has to be predictable.

Technological developments, demographical changes as well as national and international competition make education more important than ever and continuously challenge the system of educational provision. For that reason it is of immense importance that the educational system is designed to provide equal access to education for all people and enables individuals to make the educational choices that maximize their utility. Several difficulties concerning the organization of, the access to, and the financing of the educational system from early education to lifelong learning have to be overcome to provide such a system. Consequently, reforms of the educational system are constantly suggested and discussed. This thesis aims to deepen the understanding of the factors that determine educational choices, what the outcome of the choices is and how policy reforms influence educational decisions.

In the public debate the German educational system is often referred to as being both too diverse across federal states and a patchwork of many educational institutions. Various reforms to tackle shortcomings of the system and adapt to a changing environment have been implemented in the last years or are being discussed for future implementation. As a state-specific reform

tuition fees have been implemented in some federal states to increase the finances of the universities. The European-wide Bologna-reform has introduced the bachelor-master system to several European countries including Germany. At the level of secondary schooling, the years to earn the university entrance degree have been shortened by one year. Both reforms have decreased the age at which a young person enters the labor market. Centralized examination to receive the university entrance degree (*Abitur*) have been implemented in the federal states and the consolidation of different school types to a more comprehensive school is constantly debated and has been enforced in several federal states.

The effect of the reforms on educational attainment of the young people is not clear from an ex-ante perspective. As an example, the introduction of tuition fees in Germany has been highly controversial. Proponents argued the fees to be necessary to improve the quality of universities, stay competitive with other European countries, and provide access to academic education for an increasing number of persons eligible for entrance. Opponents worried that the fees deter school leavers, especially from a low socio-economic background, from higher education at university level. This would create further inequalities and compromise international competition as the pool of high skilled workers decreases. Similarly, the benefits of consolidating different school types to a more comprehensive system are fiercely debated. While some studies show that students profit from the separation because they are taught according to their abilities, other studies emphasize the effects of peers and argue that students profit from a more heterogeneous learning group. To make an informed decision in these debates it is necessary to know how young people and their parents react to incentives and structures within the educational system.

Apart from educational policies and the structure of the system, also the labor market creates incentives for certain educational choices. Positive economic returns to education at the individual level have been consistently found, with such returns varying by the type and level of the qualification obtained, by subject area of higher education and over time. The individual expectations on future labor market outcome in turn influence the decision on which type of education will be obtained. Studies suggest that expected earnings are important for the decision whether or not to attend university. For Germany, Fossen and Glocker (2011) find that increasing the expected earnings with a university degree by 10 percent raises the probability of students enrolling by 6.2 percentage points. Similarly, this and other studies find that increasing

risk, i.e. the variance in the payoff for education, reduces investments in education. In this thesis it will be analyzed whether the expected earnings and unemployment probabilities play a role already in the earlier secondary school decision. Further, results on what a young person can expect from their future earnings and the earnings risk from different educational fields and levels will be presented.

In my thesis I will in particular consider the structure of the German education system and two educational reforms in the analysis of educational choices and outcome. In chapter 1[1] I analyze how tuition fees affect the decision on where to study and how this affects the allocation of university students across Germany. In chapter 2[2] I compare earnings and earnings risks of graduates from different fields in university education and vocational training. Only school leavers who obtained the university entrance certificate can apply for university and choose between the university and vocational path. In the third and fourth chapter of this thesis I take one step back and analyze the secondary school choice. The role of expected lifetime earnings on the choice of the secondary school degree is analyzed in chapter 3. As it has been shown for university enrollment, my results reveal that this is already the case for the earlier secondary school degree choice, and the school reform that decreases the age a young person can enter the labor market is likely to increase the share of students with a university entrance certificate by increasing lifetime earnings. The effect of attending the highest track secondary school on later educational choices is estimated in chapter 4[3]. Additionally, in this chapter the impact of factors that are not observable by the researchers but also influence educational choices are taken under special consideration.

Methodology and data

Several methodological issues arise when estimating the determinants of educational attainment or the effect of educational attainment on wages and other outcome. Researchers are confronted by the many and inter-related decision making processes of the students, their families, teachers, administrators and policy makers (Meghir and Rivkin, 2011). To evaluate educational policies and

[1]The chapter is based on joint work with Nadja Dwenger and Katharina Wrohlich (Dwenger et al., 2012).

[2]The chapter is based on joint work with Daniela Glocker (Glocker and Storck, 2012).

[3]The chapter is based on joint work with Ronny Freier (Freier and Storck, 2012).

determinants of educational choices and outcome, I draw on various empirical strategies traditionally used in the empirical analysis of individual behavior as well as on more recently developed methods. Each study in this cumulative dissertation builds on a suitable method for the question of interest. To meet the various data requirements, I rely on a number of established survey data which I have partly supplemented with newly collected information or connected for the first time.

An extensively discussed problem when identifying the causal effect of any impact factor on human behavior is the problem of self-selection into "treatment" based on factors that cannot be observed by the researcher. Omitting a variable that has an effect on both the explanatory variable of interest and the outcome variable biases the estimate, and the causal effect of the variable of interest on the outcome cannot be identified. A variety of methods are commonly used to identify causal relationships ranging from structural models based on utility maximization to experimental and quasi-experimental approaches (Cahuc and Zylberberg, 2004).

For the structural model, hypotheses are deducted from a theoretical model that can be tested with data. The identification of the causal effects are also derived from theory. The advantage of this method is that the estimated parameters have a clear economic meaning, and can be used to predict effects of hypothetical reforms that have not yet taken place. However, it is often criticized that structural models rely on strong assumptions that need to be imposed. The quasi-experimental approaches exploit exogenous variation for the identification of the causal effect on behavior. An instrumental variable that conditional on observed characteristics randomly assigns individuals into treatment or a policy reform that only affects part of the population of interest are of use here. Since good quasi-experiments are not often found, a regression-control framework can be used to avoid a large bias from omitted variables if a dataset with many observable characteristics is available. In this approach all variables that have an effect on the explanatory variable and the outcome would have to be observed and included in the regression to compare individuals who are equal in all characteristics except for the status of treatment. However, even with extensive household surveys not all impact factors can be fully captured.

In chapter 1 I exploit a state-specific policy reform as a "natural experiment" to estimate the causal effect of tuition fees on the behavior of university applicants. With this method the difference in average behavior before and after the

reform can be compared for a group affected by the tuition fees with the before and after contrast for a comparison group. This type of difference-in-differences analysis requires a large data set to have enough information on the two groups as well as a time span that ranges from before the reform to after the reform. Access to administrative data from the German central clearing house (ZVS) allows to cover applications of students to medical schools for the years 2002 to 2008 for the analysis. Apart from being able to observe the whole population and not only a subsample, the advantage of this administrative dataset is that it contains information on true preferences of applicants, i.e., the universities they choose rather than those they are finally assigned to, this gives us the opportunity to circumvent possible supply side constraints.

In chapter 2 I more descriptively compare various fields of education within and across levels of education. An approach from financial economics is borrowed to evaluate the fields of education in terms of their investment value. To compare the investment value of the fields the trade-off between returns and risk has to be considered. Returns are estimated over the whole life cycle of an individual to account for the different lifespan and age-earnings profile depending on the field and level of education. Risk is defined as the variance of the returns across individuals with the same education and also includes the field specific unemployment probability. Returns that are standardized per unit of risk are used to rank the fields in terms of their investment value. For this analysis, a large dataset is needed that allows us to observe enough individuals in many fields of education. Administrative data that gives information on a person's educational choices as well as income is not available. Two have a large enough sample size to compare various fields of education, I use the German Labor Force Survey (Micro Census) to estimate the returns and the associated risk of the fields of education.

In chapter 3 I analyze the determinants of educational choices in secondary schooling, specifically the role of expected lifetime earnings. A choice model based on utility maximization is anaylzed. The model is than used to *ex-ante* simulate the possible effect of a reduction of years to earn the *Abitur*. The model is estimated with a combination of data from a cross-section individual survey (BIBB-Transition Survey) and a household panel study (German Socio-Economic Panel (SOEP)). The BIBB-Transition Study has the advantage that it is designed to reflect the various decisions a young person makes during his or her school career, while most other surveys only contain information on the last degree earned. Since, the dataset only contains a representative sample of

16- to 24-year-old, the SOEP is used to estimate expected lifetime earnings for the young people from the BIBB-sample.

In the last chapter of this dissertation I exploit the panel structure of the SOEP to track students over time. Further, the possibility to observe the location of a household at the community level is of great benefit in this chapter. In the study apply an instrumental variable approach is applied to estimate the effect of early school choices on later educational outcomes. Early school choices are likely to be influenced by variables that cannot be observed by the researcher (for example, ability or motivation) and at the same time have an impact on the outcome variables. The instrumental variable that is excluded from the causal model of interest in the approach is the local availability of a *Gymnasium* (upper secondary school). To measure the local availability of a *Gymnasium* new dataset on the exact location of all German *Gymnasiums* is collected from various sources. With community level codes that are available in the SOEP it is possible to merge the information on school availability to the individuals in the SOEP.

Contribution and overview

In this thesis I analyze educational choices and outcomes at different points in a student's life in Germany. I look at choices at the university entrance level as well as at the point in time when the decision about the secondary school leaving degree is made. The German education system is diverse in its options, the system varies by federal states, and various reforms have been conducted over the last years.

I will start with analyzing if students are willing to move from their home federal state to another state to avoid paying tuition fees. Student mobility is rather low in Germany. The majority of students enroll in a university within the state they obtained their secondary school diploma (Statistisches Bundesamt, 2004). Our results show that with the introduction of the state-specific tuition fees the probability of applying for a university in the home state falls by 2 percentage points (baseline: 69 percent) for high-school graduates who come from a state with tuition fees. Moreover, students with (very) good grades have an even higher probability of applying in their home state than they would have had in a scenario without tuition fees, while students with worse grades are more likely to leave. This heterogeneous effect is likely to have consequences for the composition of students in universities and can be

valuable for the consideration of the future design and implementation of a tuition fee system.

As shown in chapter 1 , prospective students react to financial aspects e.g. tuition fees. In chapter 2 I compare the monetary benefits of graduating from different fields of education. Positive economic returns to the level of education have been consistently found but not many studies differentiate by field when estimating returns to education. By comparing the returns and the earnings risk of graduating from one of 74 fields of education, it is shown that not only the level of education is important for later returns but also the chosen field. A longer university education does not always pay off against a shorter vocational training or university of applied science education. Considering earnings risks further suggests that only looking at the average returns does not always give the correct picture on what the most financially attractive educational choice is. The information on the financial returns to fields of education can be an important factor in a prospective students choice of post-secondary education.

As the option to apply for university education and being able to choose between all levels of post-secondary education is only available after earning a university entrance degree, the German *Abitur*, the decision to obtain this degree is of great importance in the German educational system. The three-track-system with its different secondary school degrees and varying options for further education makes early schooling decisions already a seminal choice for future educational and occupation paths. While in the US around 80 percent of students finish high-school and therefore are eligible to apply to university education, in Germany only around one third of young people leave the school system with a degree that allows university entrance. For that reason, the second part of this thesis deals with the choice of the secondary school degree within the German system.

In chapter 3 I compare estimates of the differences between lifetime earnings of persons with different secondary school degrees and identify the effect of the earnings expectations on educational choices. A comparison of earnings of a person with a low-qualifying school degree and vocational training as a post-secondary education and a person with a high-qualifying *Abitur* and the same level of post-secondary education indicates that a high value is attached to the *Abitur*. This is true even in a case in which the option of the *Abitur*, the possibility to enter university, is not taken up. The earnings a student can expect also influences his decision on the chosen degree. As studies on university enrollment have already shown, an increase in expected earnings with

a certain degree increases the share of students who obtain that degree. The sensitivity of earnings varies by socio-economic background and by the earlier school attendance of a student. This suggests that the share and composition of school leavers with the *Abitur* could be altered if a reform, as for example the shortening of years of schooling to the *Abitur*, increases the expected lifetime earnings.

How does the attendance of a high-qualifying school type as the *Gymnasium* in Germany affect the later educational decisions of a student? This question will be investigated in the fourth chapter. Applying OLS with many control variables and an instrumental variable approach, a significant effect of the attendance on later outcomes is found. Hence, the estimates suggest that even when comparing assumably *ex ante* equal students, the attendance of a *Gymnasium* increases the probability to enter an academic path later. Possible explanations are the reduced costs of earning the *Abitur* because a transfer to a school that offers the *Abitur* is not necessary but also better and more motivated peers and teachers could be impact factors. The results are validated by applying a new method by Altonji et al. (2005b) that determines the possible bias of the estimated effect due to unobservable variables. The results from this method indicate that a bias from unobservables is in fact too large as for us to determine with certainty if there is indeed a causal effect of the attendance of a *Gymnasium* on the outcomes of interest.

In the last chapter I conclude with the main results from this thesis, give an overview of policy implication and make suggestions for further research.

Chapter 1

Do tuition fees affect the mobility of university applicants? Evidence from a natural experiment[†]

1.1 Introduction

Education at public universities has been free of charge for the past 30 years in Germany. Recently, however, several German states re-introduced tuition fees amounting to 1,000 euro per year. In this paper we want to analyze whether the introduction of tuition fees affected the mobility of university applicants. In particular, we are interested in the question whether applicants from states that introduced tuition fees have a lower probability of applying at a university in their home state.

This question is interesting from a political and from a theoretical point of view. All German high-school alumni are allowed to apply for universities all over Germany. If the introduction of tuition fees by selected states affect the mobility of university applicants in such a way that universities in tuition fee states are avoided, applicants from states that did not introduce fees might have a lower probability to be admitted to a university in their home state. Furthermore, if tuition fees affect groups of university applicants in different

[†]This chapter is based on joint work with Nadja Dwenger from MPI for Tax Law and Public Finance and Katharina Wrohlich from DIW Berlin, see Dwenger et al. (2012).

ways, the policy might also influence the composition of students across states.

In the theoretical literature on education policy and fiscal federalism many models rely on assumptions concerning the mobility of high-school graduates, or more generally, the mobility of university applicants. For example, one typical question in this context addresses the issue whether centralized or decentralized financing of universities is optimal (e.g., Schwager, 2008). Another example is the question whether tuition fees improve the quality of higher education (e.g., Hübner, 2009a; Kemnitz, 2010). As Demange et al. (2008) show the relative importance of student and graduate mobility is essential for both the way higher education is financed and for the quality of education. Further, an increase in student mobility intensifies tax and amenity competition and thus erodes public revenues (Krieger and Lange, 2010).[4] In all of these models the assumptions concerning mobility of university applicants crucially determine the results. Our analysis goes one step beyond and investigates whether the mobility behavior of university applicants is actually affected by policy changes.

Empirical studies on the effect of tuition fees on student mobility are so far mainly based on data from the United States. In the US tuition fees vary widely across states and between universities. Further, all public universities charge out-of-state students with higher tuition fees (non-resident fee) than in-state students. The argument for this is that states are not willing to subsidize the university education of children of non-residents. Empirical results on the sign of the effect of tuition fees on enrollment are ambiguous: On the one hand, high fees may represent important academic heritage and prestige, offering greater potential future earnings to its graduates.[5] On the other hand, high tuition raises the cost of attending certain universities (price effect).

Research on student mobility has started with Tuckman (1970), who finds that student out-migration rates vary positively with average tuition fees charged to residents within a particular state. Mixon (1992) updates the data gathered by Tuckman and finds that the effect of tuition fees on out-migration remains significantly positive. Also the study by Morgan (1983), who jointly estimates non-resident tuition rates and the non-resident student's demand for

[4]Other studies focus on mobility within the European Union as an outcome of the Bologna process which has harmonized higher educational degrees over Europe. Gerard (2007) shows that imposing a student's federal state of origin to pay for the studies abroad can be a Pareto improvement, compared to a situation where the host country bears the cost. The introduction of tuition fees can mitigate the potential underprovision of higher education (Büttner and Schwager, 2004).

[5]For instance, Ehrenberg and Rizzo (2004) find that an institution's quality influences the in-state and out-of-state tuition level.

higher education, concludes that students who consider to attend out-of-state universities are significantly deterred by tuition fees. By contrast, employing cross-sectional information on student state-to-state migration flows and controlling for quality and economic conditions, Mchugh and Morgan (1984) find an insignificant effect of non-resident tuition fees on enrollment by non-resident high-school graduates. In a study based on university-level data Mixon and Hsing (1994) analyze the determinants of the ratio of resident to non-resident students for a sample of public and private academic institutions. They estimate a positive effect of non-resident tuition fees on enrollment by out-of-state high-school graduates. Their results suggest that tuition acts as a "signal" for university prestige that prevails over the price effect of non-resident tuition fees. In a more recent study Dotterweich and Baryla (2005) employ a data set which contains both information on universities and information on the economic conditions of their regional environments. Similar to the earlier studies they come up with a positive relation between non-resident enrollment and tuition in private institutions, while no significant relationship seems to exist in public institutions.

The mixed empirical evidence from the US does not allow us to make clear predictions about how the introduction of tuition fees in some but not all federal states in Germany might affect applicants' mobility. Moreover, the institutional background is very different in Germany, where tuition fees are much lower and private universities play only a very minor role.

A single other study evaluates the introduction of tuition fees in Germany Hübner (2009b) focusing on the effects of tuition fees on enrollment decisions. Hübner finds that the introduction of tuition fees in some but not all federal states has reduced the probability of enrollment in federal states charging tuition fees by 2.74%-points. As he shows in his paper, his estimate can only be a lower bound of the true effect, because high-school graduates in fee states partly move to non-fee states. By doing so, they mitigate the effect of tuition fees on enrollment probabilities in fee states.[6] To investigate the additional mobility of high-school graduates caused by tuition fees is the purpose of our study.

Table A1.1 in the appendix shows that German students are relatively immobile. In 2003 in all German states, except for Brandenburg, the majority of first year students studied in the federal state where they had obtained their

[6]Relating the true effect and the observed effect in a theoretical model of university enrollment, he recovers a true effect of 4.80%-points.

high-school leaving degree. In Bavaria, Baden-Württemberg, North Rhine-Westphalia, and Saxony, this share was even larger: In these states, more than 70 percent of first year students studied at a home university. If individuals decide to take up their studies in another state, they mostly choose their neighboring state. The share of high-school graduates moving beyond the bordering state is below 5% (cf. Figure A1.1 in the appendix; an exception are students from Saarland). Moreover, there is neither significant migration from the western states of Germany to eastern states nor vice versa. Only a very small number of students from the eastern states Mecklenburg-Western Pomerania, Saxony-Anhalt, and Thuringia move to western states (although even in this case, these shares are below 10%).

Evidence for the importance of the closeness to home in the choice of the university also comes from surveys among students. Heine et al. (2008) report that 75 percent of all first semester students state that the closeness to home is one important determinant in the choice of university.[7] All this evidence shows that - although there is some mobility, in particular into neighboring states and city states - the majority of university applicants choose a university in their home country.

The question that we analyze in our paper is whether there is a mobility reaction to state-specific education policy differences, in particular tuition fees. We exploit the "natural experiment" character of the introduction of tuition fees, because fees have not been introduced in all states but in only 6 out of 16. Based on data on applicants for medical schools by the central clearing house (ZVS) we use a difference-in-differences strategy to estimate the effect of the introduction of tuition fees on the probability to study in one's home state. Our findings show that in fact, university applicants from "fee states" have a significantly lower probability of applying at a university in their home state after tuition fees were introduced. The reaction is stronger for men than for women and for applicants with lower high-school grades.

The remainder of the paper is organized as follows: The next section describes the introduction of tuition fees and the corresponding public discussion in Germany. After that, we present our methodological approach and data in more detail in section 1.3. Section 1.4 shows the results and section 1.5 concludes.

[7]More indirect evidence on the immobility of German high-school graduates is provided in a study by Spiess and Wrohlich (2010). The authors show that the distance to the nearest university at the time of the high-school leaving exam significantly affects the decision to apply for a university.

1.2 Institutional background

In the end of the 1960s tuition fees for students at state universities were abolished in all German states. A few years later, fees were legally banned by federal legislation. From that time on students in Germany only had to pay a small enrollment fee of less than 100 euro per term for admission to a state university. However, in May 2003 six federal states[8] with a conservative government filed a constitutional law suit against the nationwide ban of tuition fees. In January 2005 the Federal Constitutional Court of Germany ruled that the law against tuition fees interfered with the rights of the German federal states to determine their education policies. Thus, federal states can decide on the implementation of tuition fees in their federal territory autonomously.

At the time the judgment about tuition fees was made the conservative federal governments of Bavaria, Baden-Württemberg, Hamburg, Lower Saxony, and Saarland announced to implement tuition fees.[9] In federal states with a governing coalition of the conservative (CDU) and social democratic party (SPD), the SPD strongly rejected tuition fees. For that reason the implementation of fees in these states (Saxony-Anhalt, Saxony) was not to be expected. Hence, after the ruling of the court in January 2005 high-school graduates could anticipate that Bavaria, Baden-Württemberg, Hamburg, Lower Saxony, and Saarland would pass legislations to implement tuition fees, while the situation in Hesse was unclear. Until May 2005 the social democratic government in North Rhine-Westphalia still strongly rejected fees, but a government change in May 2005 changed the situation and the new conservative government announced that it would introduce tuition fees as soon as possible.

Lower Saxony and North Rhine-Westphalia were the first to charge tuition fees in the fall term of 2006. Baden-Württemberg, Bavaria, and Hamburg followed in the spring term of 2007. Saarland completed the process of implementing tuition fees in the fall term of 2007. Hesse also imposed fees in the fall term of 2007, but the fees were again disestablished in the next year. So far the other states[10] have neither started any legal action to introduce fees in their states nor could tuition fees be expected from the public debate in these

[8] Baden-Württemberg, Bavaria, Hamburg, Saarland, Saxony, and Saxony-Anhalt.

[9] Thuringia was also governed by the conservative party in 2005. Still, Thuringia's prime minister declared not to raise tuition fees for university students. Hesse's conservative government was in favor of tuition fees, but the state constitution constrained the political decision-making on tuition-fees.

[10] Mecklenburg-Western Pomerania, Rhineland-Palatinate, Schleswig-Holstein, Bremen, Brandenburg, Saxony, Saxony-Anhalt, and Thuringia.

states.

Despite the fact that states have the undivided power to decide on tuition fees, fees have been rather uniform across the states that introduced fees. Most students have to pay a fee of 500 euro per term, leading to an investment of 1000 euro per academic year. In Bavaria and North Rhine-Westphalia the implementation of tuition fees is decentralized, meaning that universities decide on the fees autonomously. Nevertheless, most universities in these states charge 500 euro.[11]

The legal and political discussion about tuition fees was highly visible in the media. Nationwide newspapers and magazines as *"UniSpiegel"* and the *"Frankfurter SonntagsZeitung" (FAS)*, among others, continuously published dossiers on the political debate on tuition fees and actively released estimates on where and when fees were going to be imposed. Shortly before the Constitutional Court's ruling, the *"FAS"* published an overview of the federal plans suggesting that Bavaria, Baden-Württemberg, Hamburg, Lower Saxony, North Rhine-Westphalia, Saarland, and Saxony-Anhalt would be raising tuition fees, while Hesse's plans were described as ambiguous. The same situation was predicted in March of the same year by the magazine "*Studi-Info*", that is distributed by the central clearing house.[12] A regularly up-dated dossier in the online edition of *"UniSpiegel"* has summarized all actions and decisions made in the process of the implementation. For an overview of the public debate and the states where tuition fees were actually introduced see Table 1.1.

University applicants who applied for university in May-July 2005 were the first cohort to know with certainty that they would have to pay tuition fees for their studies in some federal states, while studying would continue to be free of charge in other states. Furthermore, they could distinguish between states charging tuition fees in the near future and states without plans to impose fees.

1.3 Estimation strategy and data

In order to evaluate the effect of the introduction of tuition fees on the mobility of university applicants we exploit the variation in the introduction of

[11] Only two universities that have a medical school charge lower fees of 350 euro and 275 euro (Bielefeld and Münster in North Rhine-Westphalia).

[12] All high-school graduates who wish to apply for medical school in Germany have to apply at a central clearing house called "*Zentralstelle für die Vergabe von Studienplätzen" (ZVS)*. See next section.

Table 1.1: Public debate on tuition fees

State	Estimates after the Ruling (26.01.2005)			Actual Development
	FAS (Jan 2005)	StudiInfo (March 2005)	UniSpiegel (May 2005)	Fees since
Baden-Württemberg	X	X	X	Spring 2007
Bavaria	X	X	X	Spring 2007
Hesse	?	X	?	Fall 2007-Fall 2008
Hamburg	X	X	X	Spring 2007
Lower-Saxony	X	X	X	Fall 2006
North Rhine-Westph.	–	–	X	Fall 2006
Saarland	X	X	X	Fall 2007
Rhineland-Palatinate	–	–	–	–
Saxony-Anhalt	?	X	–	–
Berlin	–	–	–	–
Brandenburg	–	–	–	–
Bremen	?	–	–	–
Mecklenb.-Western P.	–	–	–	–
Saxony	–	–	–	–
Thuringia	–	–	–	–
Schleswig-Holstein	–	–	–	–

Sources: Frankfurter Allgemeine Sonntagszeitung, 23.01.2005, Nr.3; StudiInfo, issue Wintersemester 2005/06, "Wieviel kostet das Bezahlstudium?"; UniSpiegel online (http://www.spiegel.de/unispiegel/studium/).
Notes: (X/?/–) indicates fees expected/unclear/no fees expected.

tuition fees across states as a "natural experiment". As usual in the evaluation literature, we cannot observe the behavior Y_i of an individual (in our case, the decision to apply for a university in one's home state) under both scenarios, with and without treatment. However, we argue that we can take treatment, i.e., living in a state that introduced tuition fees, as exogenous and can therefore compare the average behavior of individuals living in the two different state groups. Let us denote the behavior of individuals who live in states that introduced tuition fees as $Y_i|G = 1$ and the behavior of those who live in the other group of states as $Y_i|G = 0$. The effect of treatment G on the application behavior could then be calculated by comparing the average behavior across groups, i.e., $(\overline{Y}|G = 1) - (\overline{Y}|G = 0)$. However, if "state effects" are present that are common to the group of states that introduced tuition fees, this difference does not give the causal effect of introducing tuition fees. In order to control for this potential common state effect, we employ a difference-in-differences strategy that eliminates all time-invariant differences. Let us denote the period before treatment as $T = 0$ and the period after treatment as $T = 1$. Then

we can calculate the effect of tuition fees Δ as

$$\begin{aligned}\Delta &= \left((\overline{Y}|G=1,T=1)-(\overline{Y}|G=0,T=1)\right) \\ &\quad -\left((\overline{Y}|G=1,T=0)-(\overline{Y}|G=0,T=0)\right). \end{aligned} \tag{1.1}$$

We argue that all university applicants living in a state that was considered to introduce tuition fees in the latest newspaper article ("*UniSpiegel*") were subject to treatment after the Constitutional Court's decision in January 2005. In spring 2005, it was known that these states would start legal procedures to introduce tuition fees. Since tuition fees have to be paid over the whole time of studying and not only at the beginning, we argue that there is a treatment effect already for those who applied for university in spring 2005. We will later also perform sensitivity checks to see whether a treatment effect can be found later, when the states had actually started to levy tuition fees, which was fall term 2006 in Northrhine-Westphalia and Lower Saxony and 2007 in the other "tuition states".

Note that one problem with our identification strategy is that up to the extent that university applicants are mobile, also individuals in the control group might be affected by the reform. Applying in (non-home) states that introduced tuition fees likely became less attractive after the reform. As a consequence, the probability of applying at a university in the home state might have also increased for individuals in states of the control group due to the reform. If this is the case, our estimation yields an upper bound of the true effect on the treated individuals. However, we argue that we get a result close to the true effect by taking advantage of the fact that there is only very little migration from east German applicants to western states and vice versa, although there is migration within both groups of states (cf. Figure A1.1 in the appendix). Since no east German state introduced the fees, we can alternatively define the control group consisting only of states in east Germany in order to get a result that is closer to the true effect. We will refer to this point below.

Our difference-in-differences analysis of the effect of tuition fees on applicants' mobility requires a broad data set including all federal states. We have access to a database of the German central clearing house (ZVS) covering applications for the years 2002 to 2008. The following six subjects are centrally administered and part of our data set: medicine, pharmacy, animal health, dentistry, psychology, and biology. For these subjects, the data set is compre-

hensive, since all individuals who want to study one of these subjects necessarily have to apply with the central clearing house. Applicants between 2002 and 2004 were allowed to apply for two subjects at a time. In that case we only include the first subject choice of the applicant to avoid multiple counting. Multiple applications have not been possible between 2005 and 2008.

Note that one advantage of these data is that they contain information on true preferences of applicants, i.e., the universities they want to go, not actually chosen universities, which might be affected by supply side constraints. To determine the effect of tuition fees on applicants' mobility, we define the variable "home application" if a person applies to a university which is located in the federal state she passed her high-school diploma in. This measure is based on applicants' first preference.[13] This seems justified as the first-ranked university is of great importance in the application because the allocation of seats at university follows a priority-based mechanism.[14]

In addition to information about university preferences and home state of the applicants, the data set records individual characteristics such as average grade in the high-school diploma, age, and sex. For our empirical analysis, we only keep applicants for medicine and dentistry. Psychology and biology were affected by the introduction of bachelor studies within the Bologna process and seats for bachelor students are no longer centrally administered. We further exclude animal health because animal health can only be studied in four of the German federal states, i.e., not all applicants have the chance to study this subject at a home university.

Since applicants who have not received their university entrance diploma in Germany can never be "home applicants", we exclude these individuals from our data set. We further exclude applicants from Brandenburg and Bremen because they cannot apply in their home federal state as there are no medical schools located in these two states. By far most of the students start studying in fall;[15] we therefore restrict our analysis to applications for the fall term.

[13]Every applicant may rank up to six universities she applies to. Further, individuals may apply within three procedures applied sequentially. We only consider the first preference in the first procedure (procedure A). If an individual does not apply in procedure A, the first preference in Procedure U is taken.

[14]As is extensively discussed in Braun et al. (2010) the first preference in the first procedure should not be subject to strategic behavior of the applicants. This is because applicants who are admitted in the first procedure are not allowed to take part in the following two procedures even though these applicants generally have very good chances of being admitted to their preferred university in the last procedure (procedure U).

[15]This is because not all universities offer admission in spring and because high-school graduates in Germany are awarded their A-levels in May and June shortly before application

Table 1.2: Number of applicants across federal states before/after the introduction of tuition fees

State State	"Home" applicants		"Non-Home" applicants		
	Before (2002-2004)	After (2005-2008)	Before (2002-2004)	After (2005-2008)	Total
	Panel A. Without tuition fees				
Berlin	3,796	5,399	648	2,224	12,067
Hesse	3,398	4,760	3,167	5,613	16,938
Mecklenburg-Western Pomeria	1,112	2,003	551	1,166	4,832
Rhineland-Palatinate	1,725	2,227	2,082	3,868	9,902
Saxony	3,619	5,235	1,168	2,902	12,924
Saxony-Anhalt	1,294	2,423	1,055	2,103	6,875
Schleswig-Holstein	1,499	2,155	1,504	2,779	7,937
Thuringia	1,598	2,015	1,265	2,552	7,430
Without tuition fees	**18,041**	**26,217**	**11,440**	**23,207**	**78,905**
	Panel B. With tuition fees				
Baden-Wuerttemberg	11,149	14,086	3,408	8,903	37,546
Bavaria	11,017	14,310	3,053	7,286	35,666
Free and Hanseatic City of Hamburg	1,916	2,434	509	1,427	6,286
Lower Saxony	4,695	6,870	3,887	7,601	23,053
North Rhine-Westphalia	16,211	22,700	4,705	11,262	54,878
Saarland	815	1,093	298	825	3,031
With tuition fees	**45,803**	**61,493**	**15,860**	**37,304**	**160,460**
Total	**63,844**	**87,710**	**27,300**	**60,511**	**239,365**

Source: ZVS data on applicants, waves 2002 - 2008 (fall term).

This leaves us with a total number of 239,365 individuals over the years 2002 to 2008.

Table 1.2 shows the distribution of applicants across federal states. The upper panel of Table 1.2 shows the number of applicants living in states without tuition fees while the lower part gives the corresponding information for federal states charging fees. As we can see from the table, about one-third of the individuals (78,905) live in a state without tuition fees, while about two-thirds (160,460) live in a federal state charging tuition fees. In the group of those living in a state without tuition fees 44,258 individuals apply for a university within their home state, and another 34,647 apply for a university located outside their home state. In the other group, 107,296 individuals apply within their home state and 53,164 outside their home state.

As pointed out earlier most individuals apply for a university located in their home state. This is also what we find in the present data set. Over all years and states, 63 percent of applicants in our data set rank a university in their home state as first preference. There are only a few states, namely Hesse,

deadlines for the fall term in July.

Rhineland-Palatinate, Schleswig-Holstein, and Thuringia, in which more than 50 percent apply to non-home universities. Interestingly, applicants in federal states charging tuition fees seem to be particularly immobile; among these federal states, there is none whose students by majority apply in another federal state. Similar to the overall picture of mobility, applicants for medical school migrate within eastern and within western Germany but there is nearly no exchange between these two parts (cf. Figure A1.2 in the appendix).

In addition to the total number of applicants, we are also interested in differences in personal characteristics of applicants to control for changes in the composition of applicants over time and to analyze the effect of tuition fees on the behavior of sub-groups of applicants. Table 1.3 contrasts the characteristics of those individuals living in a state without tuition fees and those living in a state with tuition fees. It further distinguishes the time period before and after the introduction of tuition fees in some federal states. From Table 1.3 we can see that there are no important differences between the group of controls and the treated. The average applicant is about 21 years old. Further, average grades for the treatment and the control group are virtually identical. The average applicant has a grade of 2.3.[16]

1.4 Results

To identify the effect of tuition fees on the mobility of applicants who graduated from high school in a state where fees were to be implemented, we estimate the probability that a person applies for a university in his or her home state using probit models. Let y_i^* denote a latent variable such as the propensity to apply for a university in one's home state (see equation 1.2). According to the difference-in-differences strategy explained in section 1.3, the explanatory variables include a dummy variable indicating the period after the introduction of the tuition fees ("after"), a dummy variable indicating the group of states that introduced fees ("fee state") as well as an interaction term of the two. The coefficient of this interaction term, β_3, gives the causal effect of tuition fees on the probability to apply in one's home state. Furthermore, we control for sex, age, grade of the high-school diploma as well as for an overall time trend, summarized in X_i. The vector of control variables moreover includes the variable

[16]In Germany grades are measured on a 1 to 6 scale with 1.0 being the top grade. The lowest passing grade is 4.0. The last column of the table displays the share of applicants in the different grade groups.

Table 1.3: Descriptive statistics

Personal characteristics	Control group (without tuition fees)		Treatment group (with tuition fees)		
	Before (2002-2004)	After (2005-2008)	Before (2002-2004)	After (2005-2008)	Total share
Age (years)	21.11	21.24	21.37	21.41	-
	(2.79)	(2.88)	(2.85)	(2.79)	
Male (%)	0.37	0.36	0.42	0.40	39.5%
	(0.48)	(0.48)	(0.49)	(0.49)	
Grade (points)	2.32	2.22	2.39	2.29	-
	(0.63))	(0.63)	(0.63)	(0.63)	
Grade group 1: 1.0 - 1.5 (%)	1.23	1.23	1.23	1.22	9.8%
	(0.14)	(0.14)	(0.14)	(0.15)	
Grade group 2: 1.6 - 2.0 (%)	1.72	1.72	1.72	1.73	20.3%
	(0.14)	(0.14)	(0.14)	(0.142)	
Grade group 3: 2.1 - 2.5 (%)	2.20	2.19	2.21	2.20	28.4%
	(0.14)	(0.14)	(0.14)	(0.14)	
Grade group 4: 2.5 - 3.0 (%)	2.69	2.68	2.69	2.69	24.5%
	(0.14)	(0.14)	(0.14)	(0.14)	
Grade group 5: 3.0 - 4.0 (%)	3.23	3.22	3.25	3.25	17.00%
	(0.19)	(0.19)	(0.20)	(0.20)	
Total	29,481	49,424	61,663	98,797	239,365

Source: ZVS data on applicants, waves 2002 - 2008 (fall term). Standard deviation in parentheses.

"top university". This is a dummy variable indicating if an individual comes from Bavaria, Baden-Württemberg or Berlin. We restrict "top universities" to these three states, since the medical schools ranked best are located in these states.[17] Therefore, applicants from these states might have a higher probability to stay in their home state, since it offers one of the best or most popular medical schools. ε_i is an error term following a normal distribution.

$$y_i^* = \beta_1 * after_i + \beta_2 * feestate_i + \beta_3 * after \times feestate_i + \gamma' X_i + \varepsilon_i, \quad (1.2)$$

1.4.1 Behavioral response

Table 1.4 summarizes the main estimation results (marginal effects). First of all, we find that applicants from "fee states" have generally a higher probability to apply for a university at home, as has already been suggested by the descriptive statistics in section 1.3. Second, there is a general time trend in that mobility in all states is higher in the years after tuition fees have been announced in some states. The interaction term of the two variables is strongly significant and indicates that on top of that trend, applicants from fee states have a significantly lower probability to apply for a university in their home

[17] CHE University Ranking for medical schools, year 2006.

Table 1.4: Estimation results (marginal effects)

Treatment period	Basic Model 2005-2008		Sensitivity check 1 2006-2008		Sensitivity check 2 2007-2008	
Variable	Marg. Eff.	Std. Err.	Marg. Eff.	Std. Err.	Marg. Eff.	Std. Err.
	(1)	(2)	(3)	(4)	(5)	(6)
Fee State	0.1218***	0.0037	0.1200***	0.0038	0.1157***	0.0038
After	-0.1528***	0.0054	-0.1650***	0.0058	-0.1623***	0.0062
After * Fee State	-0.0493***	0.0044	-0.0397***	0.0046	-0.0435***	0.0051
Male	-0.0074***	0.0021	-0.0060***	0.0023	-0.0066***	0.0025
Age	0.0003	0.0004	0.0003	0.0005	-0.0003	0.0005
Top Universtity	0.0381***	0.0024	0.0414***	0.0027	0.0475***	0.0029
Grade[1]						
1.0-1.5	-0.0108**	0.0042	-0.0114**	0.0046	-0.0182***	0.0051
1.6-2.0	-0.0019	0.0035	-0.0046	0.0038	-0.0078	0.0042
2.1-2.5	-0.0462***	0.0032	-0.0462***	0.0035	-0.0425***	0.0039
2.5-3.0	-0.0295***	0.0032	-0.0265***	0.0035	-0.0244***	0.0039
Year Dummies						
fall 2003	-0.0142***	0.0043	-0.0142***	0.0043	-0.0142***	0.0043
fall 2004	-0.0135***	0.0042	-0.0134***	0.0042	-0.0134***	0.0041
fall 2005	0.0508***	0.0034	–	–	–	–
fall 2006	0.0238***	0.0036	0.0217***	0.0037	–	–
fall 2007	0.0058*	0.0036	0.0038	0.0037	0.0043	0.0037
Procedure A[2]	0.0548***	0.0039	0.0623***	0.0044	0.0594***	0.0046
Number of Observations	239,365		199,459		163,861	

Source: Estimations based on ZVS data on applicants, waves 2002 to 2008 (fall term).
Notes:(***/**/*/): indicates significance at the 1%- / 5%- / 10%-level. Control group in all three specifications: years 2002 to 2004.
[1] Grades in high-school diploma. Declining from 1 to 4. Grade group 5 with grades 3.0 to 4.0 serves as base category.
[2] As noted earlier we only consider the first preference of applicants. This first preference stems from procedure A where applicants with excellent grades have a very good chance of being admitted to their preferred university or from procedure U which allows universities to admit students according to their own preferences (for details on these procedures cf. Braun et al., 2010). Since there may be differences across procedures, we control for the procedure preferences have been stated for.

state. This probability is reduced by roughly 5 %-points (baseline 63 percent).

This result is robust to different definitions of the treatment period: Table 1.4 shows estimation results when we change the treatment period from 2005-2008 (basic model) to 2006-2008 (columns 3 and 4) and 2007-2008 (columns 5 and 6), respectively. We estimate these specifications to check whether the actual introduction of the tuition fees has an additional effect on top of the "announcement effect". We do not find support for this hypothesis, since the interaction term is roughly of the same magnitude as in the first specification. Also the effect of the control variables such as sex and grade of the high-school diploma is constant across the three different specifications. We find that applicants with very good grades (grade category 1.0-1.5) have a lower

probability to apply in their home state after tuiton fees were introduced than applicants with lower grades. As expected, applicants living in a state with at least one top-ranked medical school have a higher probability to apply at home.

1.4.2 Different control group to rule out spill-overs

As mentioned earlier, up to the extent that university applicants in the control group have been mobile and applied in a different state (now charging tuition fees) than their home state before the reform, we are overestimating the true effect on the treated individuals. However, we argue that, since there is very little east-west or west-east migration, we can confine our control group to eastern states and get an estimate that should be close to the true effect. As Figure A1.2 in the appendix shows, the migration flows of medical school applicants in this respect are not different from those of all first year students. Most migration is observed between neighboring states and there is very few east-west or west-east migration.

Thus, in Table 1.5, we show estimation results where the three western states without tuition fees, i.e., Hesse, Rhineland-Palatinate, and Schleswig-Holstein, are excluded. Indeed, compared to the previous results, the marginal effect of the interaction term capturing treatment is smaller in this case, indicating that including the western states in the control group leads to an upward bias of the true effect. The interaction term, however, is still strongly significant and shows that the introduction of tuition fees reduces the probability of an applicant from a tuition fee state to apply at home by 2 %-points (baseline 69 percent).[18] We argue that this estimate comes close to the true effect, since there has been relatively little migration from eastern to western states before the reform.

[18] Another sensitivity check we performed is an estimation where Sachsen-Anhalt is left out of the control group, since in the year 2007, the number of high-school graduates doubled due to a schooling reform. In this case, the point estimate is a bit lower, however not statistically significantly different from the one reported above. Moreover, we performed a so-called "placebo-treatment" exercise where we randomly assigned states from the control group into a placebo treatment group (see Table A1.3 in the Appendix). This "placebo experiment" is meant to show that the effect that the difference-in-differences analysis yields is the effect of the reform and not some artefact of other factors. This is confirmed since we do not find significant effects of the placebo reform.

Table 1.5: Estimation results (marginal effects) with eastern states as control group

Treatment period	Basic Model 2005-2008		Sensitivity check 1 2006-2008		Sensitivity check 2 2007-2008	
Variable	Marg. Eff.	Std. Err.	Marg. Eff.	Std. Err.	Marg. Eff.	Std. Err.
	(1)	(2)	(3)	(4)	(5)	(6)
Fee State	0.0196***	0.0045	0.0173***	0.0045	0.0140***	0.0045
After	0.1756***	0.0061	-0.1891***	0.0066	-0.1863***	0.0073
After * Fee State	-0.0239***	0.0053	-0.0154***	0.0056	-0.0205***	0.0061
Male	-0.0028	0.0022	-0.0009	0.0024	-0.0012	0.0026
Age	0.0004	0.0004	0.0003	0.0004	-0.0004	0.0005
Top Universtity	0.0370***	0.0024	0.0402***	0.0026	0.0460***	0.0028
Grade[1]						
1.0-1.5	-0.0027	0.0045	-0.0047	0.0049	-0.0120**	0.0054
1.6-2.0	-0.0062*	0.0037	-0.0094**	0.0041	-0.0126***	0.0044
2.1-2.5	-0.0589***	0.0034	-0.0586***	0.0038	-0.0551***	0.0041
2.5-3.0	-0.0353***	0.0035	-0.0315***	0.0038	-0.0296***	0.0041
Year Dummies						
fall 2003	-0.0221***	0.0047	-0.0220***	0.0046	-0.0219***	0.0046
fall 2004	-0.0223***	0.0045	-0.0222***	0.0045	-0.0220***	0.0044
fall 2005	0.0456***	0.0036	–	–	–	–
fall 2006	0.0242***	0.0038	0.0219***	–	–	–
fall 2007	0.0072***	0.0038	0.0050	0.0038	0.0052	0.0038
Procedure A[2]	0.0540***	0.0041	0.0616***	0.0046	0.0594***	0.0049
Number of Observations	204,588		170,523		140,158	

Source: Estimations based on ZVS data on applicants, waves 2002 to 2008 (fall term).
Notes: (***/**/*/): indicates significance at the 1%- / 5%- / 10%-level. Control group in all three specifications: years 2002 to 2004.
[1] Grades in high-school diploma. Declining from 1 to 4. Grade group 5 with grades 3.0 to 4.0 serves as base category.
[2] As noted earlier we only consider the first preference of applicants. This first preference stems from procedure A where applicants with excellent grades have a very good chance of being admitted to their preferred university or from procedure U which allows universities to admit students according to their own preferences (for details on these procedures cf. Braun et al., 2010). Since there may be differences across procedures, we control for the procedure preferences have been stated for.

1.4.3 Heterogeneity in the behavioral response

In the next step, we further exploit information on individual characteristics available in our data set and check for heterogenous effects for applicants with different grades. We estimate a model in which we additionally interact the interaction term of "fee-state" and "after" with dummy variables indicating different grade groups. As can be seen from the results summarized in Table 1.6, we find that applicants with very good grades (average grades 1.0 - 1.5) have an even higher probability of applying in their home state than they would have had in a scenario without tuition fees. On the other hand, applicants whose grades are worse have a higher probability of applying in another state. This implies that applicants with very good grades are more willing to pay the tuition fee and/or are less willing to leave their home state, despite the fee. The reason might be that they are more confident in their ability to complete university and find a high-income job. Another explanation could be that good students believe that the introduction of tuition fees will increase the quality of universities in tuition states and therefore choose those universities. Several universities waive students with stipends and with the best grades in the first university exams from fees; since grades in the high-school diploma are probably correlated with grades in university exams and with the probability of obtaining a stipend, it is also possible that excellent applicants hope for being exempted and hence more weakly react to the introduction of fees. Grades in the high-school diploma might also be correlated with parental income, which possibly also prevents very good, i.e., richer applicants from a reaction on the introduction of tuition fees.

While we can only speculate about the reason for the heterogenous effects, tuition fees in some but not all states certainly have consequences for the composition of students in universities across Germany. If the "high ability" students stay in the tuition states, universities in states without fees are left with the "less able" students or, more exactly, are only able to attract "less able" students. This could in turn amplify the process of implementing "Elite-Universities". Besides, we find that men are more responsive to the introduction of tuition fees than women are.[19]

[19]More detailed results on this finding can be obtained from the authors upon request.

Table 1.6: Estimation results with eastern states as control group: by grade

Variable	Marginal Effect	Standard Error
Grade1 * After * Fee State[1]	0.0863***	0.0075
Grade2 * After * Fee State	0.0101	0.0069
Grade3 * After * Fee State	-0.0464***	0.0067
Grade4 * After * Fee State	-0.0341***	0.0069
Fee State	0.0174***	0.0045
After	-0.1748***	0.0061
After * Fee State	-0.0132*	0.0072
Male	-0.0027	0.0022
Age	0.0005	0.0004
Top University	0.0363***	0.0024
Grade[2]		
1.0-1.5	-0.0473***	0.0062
1.6-2.0	-0.0113**	0.0051
2.1-2.5	-0.0351***	0.0047
2.6-3.0	-0.0183***	0.0048
Year Dummies		
fall 2003	-0.0226***	0.0047
fall 2004	-0.0232***	0.0045
fall 2005	0.0475***	0.0036
fall 2006	0.0256***	0.0038
fall 2007	0.0081**	0.0038
procedure A[3]	0.0523***	0.0041
Constant	0.6310***	0.0291
Number of Observations	204,588	

Source: Estimations based on ZVS data on applicants, waves 2002 to 2008 (fall term).

Notes: (***/**/*): indicates significance at the 1%- / 5%- / 10%-level.

[1] The interaction variables with grades are jointly significant (test statistics: chi2(4) = 365.81.)

[2] Grades in high-school diploma. Declining from 1 to 4. Grade group 5 with grades 3.0 to 4.0 serves as base category.

[3] As noted earlier we only consider the first preference of applicants. This first preference stems from procedure A where applicants with excellent grades have a very good chance of being admitted to their preferred university or from procedure U which allows universities to admit students according to their own preferences (for details on these procedures cf. Braun et al., 2010). Since there may be differences across procedures, we control for the procedure preferences have been stated for.

1.5 Conclusion

This paper contributes to the small empirical literature on changes in applicants' mobility if tuition fees are introduced. Knowing the size of applicants' reaction is important from both a political and an academic point of view. Politically, it is of great interest, since all German high-school graduates are allowed to nationwide apply for universities. If the mobility of university applicants is affected in such a way that universities in tuition fee states are avoided, this may entail higher costs for those states who did not introduce tuition fees.

Because applicants may react differently depending on their personal characteristics, tuition fees might also affect the composition of applicants. We estimate the size of applicants' reaction by exploiting a "natural experiment". In particular, we take advantage of the fact that recently, several but not all federal states in Germany introduced tuition fees. Arguing that the treatment, i.e., living in a state that introduced tuition fees, is exogenous we use a difference-in-differences approach to obtain the causal effect of fees on the probability to apply for a university in one's home state. In so far as, before the reform, individuals from non-fee states had applied in states nowadays charging fees and have been deterred from doing so after the reform, we overestimate the true effect. However, we argue that we get a result close to the true effect by taking advantage of the fact that there is only very little migration from east German applicants to western states and vice versa. We thus define the control group consisting only of states in east Germany in order to get a result that is close to the true effect. We find that applicants from fee states have a significantly lower probability of applying for a university in their home state once tuition fees have been introduced. The probability of applying at home is reduced by roughly 2 %-points (baseline probability 69 percent).[20]

As our results show, this average effect in fact hides important differences between individuals. For example, we find that applicants with lower high-school grades react more strongly to the introduction of fees and are more likely to apply in a non-home state. In contrast, applicants with excellent high-school grades even have a higher probability to stay in their home state after tuition fees have been introduced. These heterogenous behavioral effects lead to differences in the composition of students across states. In particular,

[20]Note that the change in mobility might well be a short-term effect. It might be that universities in fee states invest in quality and thus attract more students than universities in non-fee states in the long run. This question can only be answered in several years when data are available.

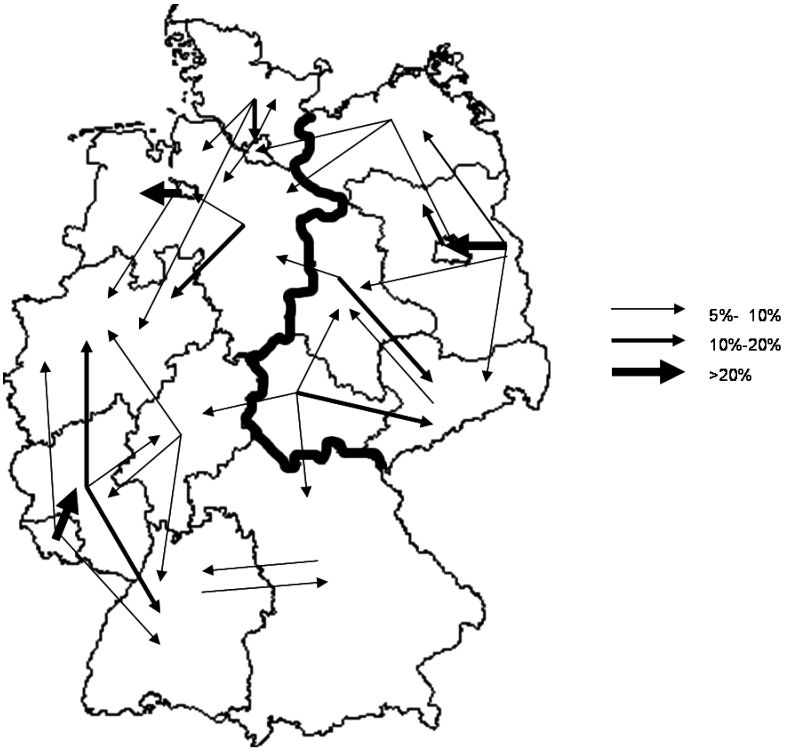
this implies that the advantage of "fee states" is twofold. First, they increase their budget by collecting fees, and second, they attract applicants with better grades.

Against this background, the political discussion on centralized versus decentralized finance of higher education is likely to continue. It might be that other federal states will follow and introduce general tuition fees. Another possibility is that the idea of non-fee states to introduce fees for non-resident applicants (so-called "Landeskinderregelung") might regain importance. Such a regulation has shortly been in place in Hamburg. The criteria, however, whether fees had to be paid were not conditioned on the state of the high-school exam but rather the residential state of the applicant ("Hauptwohnsitz"). By moving to Hamburg, thus, every applicant could avoid the fees. In the United States and in several Canadian provinces, public research institutions charge out-of-state students higher tuition fees than in-state students, presumably because state taxpayers do not want to subsidize higher education of non-taxpayers from other states. Several states in the US have combined this price discrimination between in-state and out-of-state residents with reciprocity agreements between neighboring states that allow non-resident students from a neighboring state to attend the public institution at less than the normal out-of-state (see Ehrenberg and Rizzo, 2004). A similar system of compensatory transfers exists in Switzerland at an inter-cantonal level. In the German context, such agreements might be interesting for small states who cannot afford to offer university education in all subjects and might also encourage universities to achieve cost efficiencies by specialization. Another possibility to compensate non-fee states for additional non-resident students' enrollment might be a reform of the financial equalization scheme that takes university education into account.

1.6 Appendix

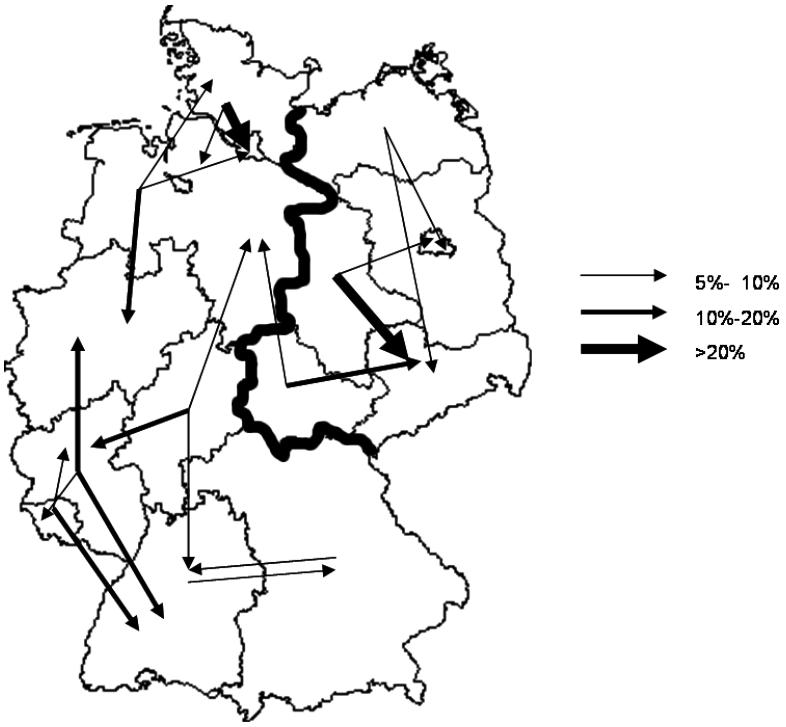
1.6.A Tables and figures

Figure A1.1: Mobility of first year students (2003)



Source: Own depiction. Figure based on Table A1.1.

Figure A1.2: Mobility of applicants for medical schools (2003)



Source: Own depiction. Figure based on Table A1.2.

Table A1.1: Mobility of first year students in 2003: Distribution of students over states (in percent)

State of study	Home State															
	East Germany						*West Germany*									
	B	BB	MV	SN	SA	TH	HB	HE	RP	SH	BW	BV	HH	NS	NRW	SL
East Germany																
Berlin (B)	62.80	22.87	7.56	1.71	3.50	1.77	2.26	0.98	0.81	1.59	1.48	0.89	1.81	1.42	1.02	0.52
Brandenburg (BB)	15.36	33.10	2.33	1.83	1.74	0.64	0.27	0.35	0.23	0.53	0.33	0.21	0.51	0.51	0.26	0.16
Mecklenb.-Western Pomeria (MV)	2.93	6.09	57.07	0.82	1.40	0.78	0.74	0.23	0.26	3.21	0.22	0.15	1.27	1.06	0.28	0.08
Saxony (SN)	2.81	12.67	4.64	71.79	13.11	13.64	0.94	0.87	0.75	1.28	1.21	1.20	0.72	1.24	0.71	0.38
Saxony-Anhalt (SA)	2.58	5.63	2.04	6.23	56.24	5.27	0.61	0.47	0.44	0.79	0.45	0.45	0.69	1.93	0.43	0.41
Thuringia (TH)	1.05	2.12	1.17	4.17	4.94	53.33	0.37	0.81	0.57	0.67	0.48	0.74	0.40	0.62	0.33	0.25
West Germany																
City of Bremen (HB)	0.41	0.57	1.06	0.23	0.42	0.25	60.82	0.29	0.23	2.09	0.23	0.18	1.71	6.88	0.45	0.16
Hesse (HE)	1.91	2.09	1.51	2.05	2.33	5.24	1.85	69.64	9.43	2.75	3.12	2.25	1.50	3.85	3.26	2.57
Rhineland-Palatinate (RP)	0.52	0.60	0.67	0.57	0.47	0.84	0.54	7.26	53.20	0.98	2.23	0.74	0.37	0.97	1.58	25.25
Schleswig-Holstein (SH)	0.62	1.03	4.88	0.31	0.55	0.52	2.73	0.38	0.32	50.95	0.25	0.20	7.06	2.84	0.49	0.08
Baden-Württemberg (BW)	1.61	2.16	1.72	1.81	1.90	2.60	2.90	5.81	14.29	3.45	76.80	5.14	1.88	2.69	1.98	5.49
Bavaria (BV)	1.70	2.55	1.40	4.51	2.02	6.79	1.45	3.68	2.67	2.56	8.12	84.29	1.78	2.32	1.71	1.94
City of Hamburg (HH)	0.86	1.71	5.13	0.54	1.23	1.05	2.70	0.58	0.67	14.99	0.53	0.42	68.31	3.55	0.66	0.44
Lower Saxony (NS)	1.61	3.43	5.62	1.25	7.04	3.88	15.48	2.94	1.35	8.72	0.89	0.67	7.94	59.77	3.80	0.55
North Rhine-Westphalia (NRW)	3.13	3.18	3.13	2.06	2.96	3.28	6.10	5.48	11.80	5.32	3.27	2.36	3.96	10.19	82.80	5.06
Saarland (SL)	0.11	0.20	0.10	0.13	0.14	0.12	0.24	0.22	2.95	0.14	0.37	0.11	0.11	0.13	0.26	56.65
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Own calculations based on Statistisches Bundesamt (2004).
Notes: Figures refer to all first year students in Germany (all subjects).

Table A1.2: Mobility of applicants for medical school in 2003: Distribution of applicants over states (in percent)

Application in	Home State													
	East Germany					*West Germany*								
	B	MV	SN	SA	TH	HE	RP	SH	BW	BV	HH	NS	NRW	SL
East Germany														
Berlin (B)	84.02	8.73	3.92	5.14	3.93	3.00	1.81	4.51	3.43	2.69	1.85	4.44	2.31	1.60
Mecklenb.-Western Pomeria (MV)	4.95	68.84	2.66	2.39	2.58	1.36	1.26	4.91	2.08	1.47	3.08	4.33	2.32	0.53
Saxony (SN)	1.87	5.31	74.88	20.10	14.77	1.91	1.42	1.40	1.60	1.71	1.48	2.01	1.53	0.80
Saxony-Anhalt (SA)	1.80	1.37	3.92	56.22	3.51	0.45	0.79	1.00	0.99	0.55	0.12	1.62	0.89	0.00
Thuringia (TH)	0.40	0.68	4.92	4.31	56.40	0.73	0.39	0.40	0.27	0.47	0.12	0.32	0.14	0.27
West Germany														
Hesse (HE)	1.00	0.51	0.80	0.60	1.76	53.34	3.86	1.30	1.75	1.36	0.74	2.46	3.32	0.53
Rhineland-Palatinate (RP)	0.13	0.00	0.13	0.24	0.83	12.78	45.58	0.30	0.84	0.43	0.37	0.42	0.49	5.08
Schleswig-Holstein (SH)	0.47	4.97	0.20	0.60	0.41	0.68	0.39	48.14	0.72	0.49	4.67	5.74	2.03	0.27
Baden-Württemberg (BW)	1.34	1.37	2.86	2.15	2.79	9.32	16.56	4.41	75.57	8.89	4.31	3.87	3.19	10.96
Bavaria (BV)	0.74	0.86	3.06	1.44	4.03	3.59	2.76	1.60	7.36	78.46	1.11	2.01	1.40	1.87
City of Hamburg (HH)	0.47	4.11	0.60	1.08	0.21	1.50	0.39	21.97	1.32	0.90	77.86	8.24	1.44	0.53
Lower Saxony (NS)	1.54	1.54	1.00	4.19	7.13	7.50	1.97	6.52	1.38	1.43	2.46	54.33	4.14	0.80
North Rhine-Westpfahlia (NRW)	0.94	1.71	1.06	1.08	1.55	3.73	16.09	3.41	2.26	1.04	1.85	10.00	76.63	2.94
Saarland (SL)	0.33	0.00	0.00	0.48	0.10	0.09	6.70	0.10	0.43	0.11	0.00	0.21	0.17	73.80
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Own calculations based on ZVS data on applicants, wave 2003 (fall term).
Notes: Figures refer to the sample used in our analysis (medical subjects only), i.e., Brandenburg and City of Bremen are excluded.

Table A1.3: Estimation results: Placebo treatment (Mecklenburg-Western Pomerania and Saxony as treatment group; Saxony-Anhalt, Thuringia, and Berlin as control group)

Variable	Marg. Eff.	Std. Err.
Placebo Fee State	0.0520***	0.0079
After	-0.1741***	0.0111
After * Placebo Fee State	0.0055	0.0098
Male	0.0086*	0.0049
Age	-0.0015*	0.0009
Grade[1]		
1.0-1.5	-0.1458***	0.0104
1.6-2.0	-0.0972***	0.0090
2.1-2.5	-0.1131***	0.0085
2.5-3.0	-0.0502***	0.0087
Year Dummies		
fall 2003	-0.0127	0.0103
fall 2004	-0.0130	0.0099
fall 2005	0.0601***	0.0078
fall 2006	0.0068	0.0083
fall 2007	0.0032	0.0082
procedure A[2]	0.0629***	0.0091
Number of Observations	44,128	

Source: Estimations based on ZVS data on applicants, waves 2002-2008 (fall term) .

Notes: (*/***): indicates significance at the 1%- / 10%-level.

[1] Grades in high-school diploma. Declining from 1 to 4. Grade group 5 with grades 3.0 to 4.0 serves as base category.

[2] As noted earlier we only consider the first preference of applicants. This first preference stems from procedure A where applicants with excellent grades have a very good chance of being admitted to their preferred university or from procedure U which allows universities to admit students according to their own preferences (for details on these procedures cf. Braun et al., 2010). Since there may be differences across procedures, we control for the procedure preferences have been stated for.

Chapter 2

Risks and returns to educational fields - A financial asset approach to vocational and academic education[‡]

2.1 Introduction

The positive effects of investments in human capital on the level and evolution of earnings, employment, and other aspects of well-being is one of the most robust and important empirical finding in labor economics (see e.g. Blundell et al., 1999; Oreopoulos and Salvanes, 2011; Psacharopoulos and Patrinos, 2004). In developed countries, education is an important resource for the economy and assumed to be one of the key determinants in technological development, production and, thus, economic growth. Therefore, politicians aim at increasing the population's educational level (see e.g., European Comission (2010) - indicators, formerly the Lisbon strategy). As increasing the countries overall educational level requires individuals to invest in their education, researchers focus on the individual's (economic) benefits of education, mainly the increase in earnings due to investments into more education.

Even though the returns from investing in human capital in general are widely studied, little is known about the properties at a more disaggregated

[‡]This chapter is based on joint work with Daniela Glocker from LSE London, see Glocker and Storck (2012).

level, i.e. field specific returns to education. Standard economic models of schooling decisions (Becker, 1964; Mincer, 1974) model the average returns to years of schooling by comparing future income streams to the costs associated with an additional year of schooling but do not differentiate between different fields. To overcome the assumption of homogeneity of human capital investments, we differentiate between fields of education within and across levels of education. Borrowing from financial economics models (see e.g. Cochrane, 2001), we contribute to the literature on human capital investment by differentiating between a large variety of educational fields and by incorporating the unexplained variance of the returns, the earnings risk, into the evaluation of the benefits from education.

To learn more about the properties of returns to different types of human capital and how they compare across fields is important from both a theoretical and a political perspective. From a theoretical perspective variations in returns to educations across fields and the earnings variation within a field have important consequences for models on educational choice that usually only consider aggregated earnings streams at different levels of education as explanatory variable. By aggregating over different fields of education one might, for example, overstate the additional value of a further year of education if the additional year of education is spent in an educational program with low labor market returns.

From a political perspective it is important to know the financial attractiveness of an educational field for various reasons. First, our results can serve as an instrument to evaluate the demand for graduates on the labor market. In Germany, for example, it is controversially discussed as to whether there is a lack of graduates from engineering fields or more broadly from MINT-fields[21]. While some experts claim that there is a lack of skilled engineers and demand that politicians take action (see e.g. Anger et al., 2011), others do not share this opinion (see e.g. Brenke, 2010). Identifying the field specific returns and associated risks could serve as a tool to evaluate the demand for graduates of a certain field of education on the labor market, with high earnings and low levels of earnings variance indicating a high demand for skilled labor in a specific field.

Second, the main impact politicians have on individual investment can be assumed to be through the costs of the investment or by providing information

[21]MINT-fields include fields in mathematic, computer science, engineering, natural science and other technical fields.

on the benefits of the investment in education. One factor through which politics influence educational investments are tuition fees. Discussions about tuition fees are usually charged with the argument that the main beneficiary of education is the individual (in addition to some positive externalities), so the investment does not have to be free of charge as the individual will capture the returns to his/her investment later in life. Thus, fields with high labor market returns might be charged higher fees, while there could be an interest to keep tuition fees of subjects with smaller labor market returns but high non-pecuniary returns (for example, arts) or high social returns (for example, education) low. It could further be assumed that there is an information deficit among prospective students or incorrect perceptions about returns to fields and levels of education, which lead to inefficient sorting into the fields. In that case politicians could rely on the estimates when informing about the financial attractiveness of the various fields of education.

Altering the expected returns to different fields of education in order to navigate educational investments of prospective students, can be assumed to be an effective political instrument. Existing models estimating the effect of expected earnings streams in different fields of education on the college major choice suggest that this choice is partly guided by expected earnings and further by non-pecuniary factors as preferences or ability (see e.g. Arcidiacono et al., 2011; Arcidiacono, 2004; Berger, 1988; Beffy et al., 2012; Boudarbat and Montmarquette, 2009).

The risk associated with different types of education should not be neglected. The question of whether, empirically, human capital investments are risky is addressed by Becker (1964), who notes that there is more earnings variation among college graduates than among high school graduates. Literature on the decision to pursue higher education, incorporating risk, originates with Levhari and Weiss (1974). They find that increasing risk, i.e. the variance in the payoff for education, reduces investment to education. Subsequent studies similarly find that reducing uncertainty in returns increases educational participation (see e.g. Hartog and Diaz-Serrano, 2007; Carneiro et al., 2003; Fossen and Glocker, 2011).

The highest expected earnings are usually found for fields in social science (mainly business and law) and medical subjects, while humanities and arts are rather unattractive investments in terms of monetary returns (Walker and Zhu, 2011).[22] The authors estimate the returns to groups of subjects but the

[22]Other studies are Ammermüller and Weber (2005) and Wahrenburg and Weldi (2007) for

variance of the returns within the group of fields is not considered.

Relatively little research, thus, tries to understand how the risk-return trade-off for different human capital investments compare at the margin. Palacios-Huerta (2003) is the first to empirically analyze risk properties of various human capital returns. He presents an empirical comparison of risk adjusted human capital investments to financial investments. Christiansen et al. (2007) take up his approach and analyze the risk-return trade-off in human capital investments with Danish labor market data. Christiansen et al. (2007) and Palacios-Huerta (2003) compare the risk properties of human capital assets by applying a framework that is standard for the analysis of financial assets.

We contribute to this stream of literature by comparing the risk and returns to a large number of educational fields in Germany. Germany provides a good framework for studying returns and risk properties to different types of education for various reasons: In Germany upper secondary high school graduates can choose between vocational education, education at a university of applied science or at a university. These educational paths have different characteristics, for example, different lengths of study, qualification levels or levels of specialization. Despite the different characteristics, they offer, in a lot of cases, similar fields of education. For example, a person interested in business or manufacturing can choose between all three paths. Hence, for a decision maker it is not only interesting to know how earnings and earnings risk vary across the paths on average but also how earnings vary between the paths for one specific field. This variation in educational choices also allows us to restrict our sample to upper secondary school graduates who obtained a university entrance certificate. Due to this sample selection, a bias stemming from sorting into the fields based on ability can be assumed to be relatively small. The group can be assumed to have a rather homogenous level of general ability. Beyond the educational framework, it is interesting to evaluate the financial performance of fields of education in Germany because of the controversially discussed lack of skilled graduates in some fields of education.

Using a large German data set, the German Micro Census, we are able to estimate the returns and earnings variances for about 70 fields of education. We estimate the returns to different fields of education by extending the standard Mincer wage equation to allow for different fields of study. By analyzing the risk-return trade-off for a large number of fields, we identify fields that are

Germany, Arcidiacono (2004) for the US, Boudarbat and Montmarquette (2009) for Canada, Kelly et al. (2010) for Ireland and Chevalier (2011) for the UK.

efficient in terms of investment goods and fields that are likely to be chosen for other reasons (consumption purposes). Because students have different preferences and abilities, we also look at the efficiency of different levels of educations within a certain group of fields (e.g. engineering fields). For instance, for someone interested in engineering, we find that a university degree in manufacturing engineering is an efficient investment as there is no other engineering field that earns a higher rate of return with the same level of earnings variation. Similarly an applied science degree in precision engineering should be chosen over a university degree in electrical engineering because it yields about the same returns but at a lower variation level.[23] We find that fields in all educational paths can be efficient investments. Hence, the decision about the level of education as well as the field of education is important when deciding about investments in education.

The paper is structured as follows: The following section explains the methodology for estimating the performance measures. Section 2.3 describes our dataset. Section 2.4 provides the results of our analysis, followed by the conclusion in section 2.5.

2.2 Empirical model and methodology

2.2.1 Performance measure

As we analyze different fields of education in terms of their investment value, we need to find an adequate measure for the efficiency of each field. The literature analyzing the returns to educational subjects focuses on the returns themselves and tends to neglect the risk associated with the different investments (see e.g. Wahrenburg and Weldi, 2007). However, this might bias the evaluation of the investment value, as the risk of an investment largely influences the investment decision (see Hartog and Diaz-Serrano, 2007; Carneiro et al., 2003; Fossen and Glocker, 2011). With respect to the educational decision, one might think of unemployment risk associated with different educational qualifications that add some uncertainty with regard to the expected returns. The variation of unemployment risk across educational qualification is well documented, (see e.g. Mincer, 1991; Riddell and Song, 2011; Reinberg and Hummel, 2007). The unemployment risk may not only vary between different educational paths, but also between the field of education majored in.

[23] This is true only under the standard assumption that individuals are risk averse.

Interpreting the different fields of education as different investment strategies, we use a standard financial economics approach: The mean-variance model of Markowitz (1952). In the model, assuming that the returns are normally distributed and investors only consider the expected returns and their variances in their decision making process. Graphing the expected returns and their standard deviation in a so-called mean-variance plot exhibits all feasible investments. Depending on the individual's utility function (increasing with returns and risk-aversion), the optimal investment strategy lies on the efficient frontier, i.e. the investment which exhibits the highest returns for a given risk. We assume investment in education to be a discrete choice. Portfolios of educations are not considered in this study. For that reason, the mean-variance plot for human capital investments is a scatter-plot whereas the empirical efficient frontier for financial assets is a continuous line.

Following Christiansen et al. (2007) we use a modified version of the Sharpe-ratio (Sharpe, 1966) to formally describe those plots and to rank the different educational investments. The Sharpe-ratio is a return to variability measure that also uses the expected (excess) returns compared to a risk free alternative, standardized with its standard deviation. Since a risk free return in the context of educational choices is not straight forward, we compare the returns of a certain educational field with the (risk free) sample average returns $\overline{R}$ over all fields as a proxy for the true population average returns:

$$S_j = \frac{E[R_j - \overline{R}]}{\sqrt{VAR[R_j - \overline{R}]}}. \tag{2.1}$$

The Sharpe-ratio S_j then indicates the efficiency gain or loss from investing into educational field j compared to the average. Thus, a higher value of the Sharpe-ratio relates to a better performance of the investment.

2.2.2 Measuring the returns

To derive our performance measure, we need the returns associated with a certain field of education. Thus, we calculate the individual hourly wages in each educational field and use this information to estimate field average returns.

To obtain the returns, we use a modified version of the standard Mincer wage regression (Mincer, 1974). We allow the log hourly wage ($\log(W)$) of individual i to non-linearly increase with age. We prefer age over experience,

as we do not observe the true work experience. A constructed measure of potential experience as a linear combination of age, years of education and the general school starting age could bias our results since possible unemployment spells are not accounted for. However, our constructed measure also neglects the information on unemployment experience, which is potentially correlated to the fields of study and may effect wages due to human capital depreciation. We try to attenuate this omitted variable bias by including information on tenure in the recent job in our model.

As with the standard Mincer returns to schooling approach, estimating field specific returns might result in several problems (see Altonji et al., 2012, for a detailed overview). A major concern, first described by Willis and Rosen (1979), and frequently discussed in the context of estimating returns to education, addresses the problem of unobserved variables that might be correlated with the educational variable, i.e. motivation or ability. Unfortunately, our dataset neither includes ability measures nor retrospective information that would allow us to model the selection process into educational fields. To keep a possible ability bias small, we constrain our sample to students that passed the university entrance examination (*Abitur*) such that variation due to unobserved ability is reduced. Studies analyzing the effect of educational qualifications[24] on wages, tend to find a significant effect due to ability sorting (see e.g. Carneiro et al., 2003). In contrast to these findings, studies focusing on college majors including measures for ability conclude, that such a bias due to omitted ability variables is rather small (Berger, 1988; Arcidiacono, 2004).

The second problem we face is possible endogeneity of educational fields. We may observe the individuals in the respective fields, because they chose that field according to their expectations about the associated returns. Arcidiacono et al. (2011) show, that an increase in the expected earnings in a certain field of education has a significant positive effect on choosing this major. A possible solution for this problem would be to instrument the educational field variables, but with our dataset we are not able to construct such instrumental variables to account for this possible endogeneity. When interpreting our finding, we should keep the literature findings in mind, which indicate that our return estimates might be biased upwards.

We estimate the earnings by applying a OLS model for the working popu-

[24]Educational qualification referring to the standard Mincerian approach of an additional year of schooling, but also to studies estimating the returns of different education qualification like university or college degrees.

lation:[25]

$$\log(W_i) = \sum_{j=1}^{J} \alpha_{0j} F_i L_i + \sum_{l=1}^{L} \alpha_{1l} \text{age}_i L_i + \sum_{l=1}^{L} \alpha_{2l} \text{age}_i^2 L_i + \beta X_i + \epsilon_i, \quad (2.2)$$

with

$j = 1, ..., J \quad \text{and} \quad l = 1, ..., L$

where

$\epsilon_i \sim N(0, \sigma_\epsilon^2)$.

The logarithm of the observed hourly wage of individual i is denoted by $\log(W_i)$. F_i is a field specific dummy which indicates whether the individual graduated in the respective field j. L_i is a dummy for the educational level, i.e. if the individual graduated from university, university of applied science or finished vocational training. To get our field specific returns for each educational level, we include the interaction of F_i and L_i. As described above, we use age, both in levels and squares, interacted with the dummies indicating the educational path. Thus, we allow for a flexible age-earnings-profile across, but homogeneous within the educational path. We do not interact the fields of education with the elements of the matrix X_i, i.e. person specific and demographic characteristics like tenure in the current job, nationality, regional- and year-dummies, since we assume that those have a unique effect on the wages unrelated to the field of education. Due to well-known differences in the age-earnings-profiles between men and women, we estimate the model separately rather than including gender dummies. Furthermore, we assume that the error terms follow a normal distribution.

After estimating the individual log wages, we can calculate the log hourly wages for the working population for each educational field. Since we allowed the earnings profile to vary with age in each educational path, we take this information into account by calculating the (discounted) capital value for each investment at the time of decision. Comparing the field specific returns at an arbitrary age might bias our measure, i.e. in younger ages the vocational educations tend to have a higher return, whereas university education pays off

[25] There might be a bias resulting from non-random sample selection into work participation varying by field of education. We controlled for this possible selection using a standard Heckman estimation model (see Heckman, 1979). While we find that the selection term is significant, it does not affect our coefficient-estimates for the returns to educational fields. This finding is in line with Lauer and Steiner (2000). The Heckman estimation results are available upon request from the authors.

at a later age. Therefore, we calculate the (discounted) capital value[26] at the time of high-school graduation, the time when decisions of further educations are made. This procedure allows us a more accurate comparison between the different fields of education as different durations of educational programs are adequately taken into account. To picture the problem, Figure A2.4 and Figure A2.5 in the appendix show the age-earnings profiles for the different educational levels for men and women.

For our efficiency analysis, we are interested in the average of the estimated field specific returns net of the effect of individual characteristics. Thus, we calculate the log hourly earnings as function of field specific characteristics, taking into account the age profile for the respective educational path:

$$\begin{aligned}\hat{R}_j &= \sum_{t=0}^{T_R} \frac{1}{\gamma^t} \left(\sum_{j=1}^{J} \hat{\alpha}_{0j} F_j + \sum_{l=1}^{L} \hat{\alpha}_{1l} (19+\mathrm{t}) L_j + \sum_{l=1}^{L} \hat{\alpha}_{2l} (19+\mathrm{t})^2 L_j \right) \\ &\quad - \left(\sum_{t=0}^{T_{edu_j}} \frac{1}{\gamma^t} \left(\sum_{j=1}^{J} \hat{\alpha}_{0j} F_j + \sum_{l=1}^{L} \hat{\alpha}_{1l} (19+\mathrm{t}) L_j + \sum_{l=1}^{L} \hat{\alpha}_{2l} (19+\mathrm{t})^2 L_j \right) \right) \end{aligned} \tag{2.3}$$

with

γ : Discount factor, and

T_R : Retirement age, and

T_{edu_j} : Years of education for field j.

The fact that some fields of education require more years to graduate than others is denoted by the substraction term. This way periods with no labor income (because the individual is still in education) are accounted with zero income.[27]

As we want to compare the returns of a specific field to the average returns, we calculate the average capital value of the sample returns $\bar{R}$ over all fields:

$$\overline{\hat{R}} = \frac{1}{N} \sum_{j=1}^{J} N_j \hat{R}_j. \tag{2.4}$$

N_j denotes the number of all working persons in field j, whereas N reflects the number of all working individuals in the sample.

[26] Note that this is the capital value of the logarithm of the hourly wages and not of the actual hourly wages.

[27] Actually, students in vocational training receive a small wage and university students are eligible for student support. We view this income as a subsistence income and do not include it in the calculation of lifetime income. Further, we neglect from any moonlighting during the course of education.

Furthermore, we assume that an individual takes into account possible unemployment risk when he/she forms his/her expectations about the field specific returns. We thus weight the returns with the unemployment probability in each field calculated as ratio of unemployed individuals on individuals in labor force. Thus, with the probability $r_{ue,j} = P(\text{unemployed} = 1|F_j)$ a graduate in field j will only receive a minimum payment UBR. In Germany, unemployed persons are entitled for unemployment benefit rate, i.e. *Arbeitslosengeld 1*, which is 63 percent (67 percent for parents) of the previous net wage in the first year of unemployment. As we only have cross-sectional data, we have no information on the duration of unemployment, but since individuals with a university entrance exam have a relative small unemployment probability it is a reasonable assumption that unemployment only occurs temporarily.

$$E[\hat{R}_j] \quad = \quad (r_{ue,j} * UBR + (1 - r_{ue,j}))\hat{R}_j \tag{2.5}$$

2.2.3 Measuring the variability

The second part of the Sharpe-ratio is an indicator for the variability of the returns. The straight forward measure is the standard deviation. With our estimation approach, we are able to split the variation in the returns into an explainable part, as well as an unexplainable part, which is the residual variation between individuals. The latter one is of interest when accounting for the variability in the returns of a specific field and will be referred to as earnings risk.[28]

Our variance within a specific field j is thus defined as

$$VAR[R_j] \quad = \quad \sigma^2_{R_j} = \sum_{t=0}^{T_R} \frac{1}{\gamma^t} VAR[\epsilon_i] - \sum_{t=0}^{T_{edu_j}} \frac{1}{\gamma^t} VAR[\epsilon_i] \qquad \forall i \in j \tag{2.6}$$

with
$\epsilon_i = \log(w_i) - \widehat{\log(w_i)}$
and
γ : Discount factor, and
T_R : Retirement age, and
T_{edu_j} : Years of education for field j.

As we calculated the earnings as (discounted) capital value over the lifetime,

[28] Strictly speaking, the error term also includes factors that are not directly interpretable as earnings risk since they might be known to the individual but unobservable for the researcher.

we do the same with the variances. While more education leads to a shorter working period over the lifetime, the (non-existent) income while being in education is risk free. To account for different unemployment incidents across the fields, we explicitly include the unemployed individuals in our calculation of ϵ_i by setting their hourly wage to 63 percent of the field specific average log-wage. Thus, the higher the share of unemployed persons in a specific field, the higher the variance in the respective field will be.[29]

We now have all relevant measures: The returns and their variability which allow us to evaluate the fields of education in terms of their efficiency by calculating the modified Sharpe-ratio as:

$$\hat{S}_j = \frac{E[\hat{R}_j] - \overline{\hat{R}}}{\hat{\sigma}_{R_j}}. \tag{2.7}$$

2.3 Data and descriptives

Our empirical analysis is based on data from the German Micro Census for the years 2005 to 2009. The Micro Census is the main German labor force survey, a 1 percent representative sample of the German population. Thus, the Micro Census has the advantage of a large sample size. Starting in 2005, the survey asked each participant about his/her subject of degree as a compulsory question.[30]

Our sample is restricted to individuals who passed the university entrance exam, the *Abitur*, and finished a professional degree in either a vocational program, at a university of applied science or a university. In Germany, individuals can choose between these three options after secondary schooling. While vocational programs are open to students from all levels of secondary schooling, the university educations are open only to those who passed the university entrance examination after 13 years of schooling.[31] Depending on the field of education

[29]This assumption holds as long as unemployed persons do not dominate, then the effect would reverse, e.g. with everyone being unemployed, the variance would be eliminated since everyone would get the same "wage". But the occurrence of unemployment in our sample is overall rather low since we are only observing graduates with a university entrance diploma (see Table A2.3 and A2.4).

[30]To answer the questions is compulsory by law. Before 2005 participants were asked about their subject of degree, but the answer was voluntary, which leads to a large share of missing values and might result in a selection bias. Before 2002 only graduates from an academic institution were asked about their subject of degree in every fourth wave of the survey.

[31]During the period the individuals of our sample are observed students had to attend school for 13 years (with the exception of some eastern federal states with only 12 years) and pass the university entrance examination after the 13th year of schooling to be able to choose

the academic educations usually last between 4 to 6 years. Educational programs at a university of applied science are usually shorter than programs at a university. To account for different lengths of educational programs, we assign the median number of semesters needed to graduate to each field of study.[32] Three years of training are usually required to obtain a vocational training certificate. Hence, we assign three years to all vocational training fields.[33] Because we only have individuals in our sample who finished a professional education, the youngest person in our sample is 21 years old.[34]

The sample is further restricted to individuals younger than the official retirement age of 65 years. There is no direct question on earnings in the German Micro Census. However, the survey asks for respondent's monthly net income. For the analysis of earnings, we restrict our sample to those who report income from own labor to be their main source of income. Because only net income is available in the data set, our measure of earnings is not free of effects the tax system has on earnings. To proximate a measure for earnings which is free of effects from the tax system, we use information on family status and employment status (part-time or full-time).

Our sample is restricted to those for who we observe income from labor and to individuals who are unemployed. The second group, the unemployed, is included in the sample to calculate the field-specific unemployment rate and to account for the risk of unemployment when estimating the field-specific earnings risk. The Micro Census provides the information on income in 24 brackets. We calculate the mean for each bracket with data from the German-Socio-Economic Panel. Table A2.1 shows that the calculated means are very close to the bracket mean in all cases. In our analysis we use hourly earnings by dividing the monthly earnings by the individuals hours usually worked.

Table A2.2 shows the descriptives of our sample, which consists of 215,810 individuals, 126,314 men and 89,496 women. The average hourly net earnings for men are 16 Euros and 12 Euros for women. This wage differential is in line with estimates for the gender wage gap (Machin and Puhani, 2003). Men

between all three types of education. Our sample also includes students who left school after 12 years of education and are only eligible for university of applied science and vocational education but not for university education.

[32]The median number of semesters refer to the median number in 2003 and are taken from Wissenschaftsrat (2005a,b). We convert the median number of semesters to years of education by dividing by two (two terms per year).

[33]It is possible to shorten the vocational training time to 2 or 2,5 years for students with a university entrance certificate. Still, many students need at least 2,5 years.

[34]School entrance age of 6 years + 12 years of schooling (includes elementary and secondary education)+ 3 years of vocational education.

and women spent on average 17 years in education. Men have tenure at their current workplace of about 10 years and women of about 9 years. The level of unemployment in our sample is 5 percent for men and 6 percent for women. The table further describes the means of the additional control variables.

The large number of observations guarantees that we have sufficient observations even in educational fields that are less frequently chosen.[35] To achieve a strong validity of our results, we restrict our analysis to fields of education in which we observe the earnings of at least 300 individuals. When restricting our sample to fields with a sufficient number of observations we have 74 fields left for our analysis. For men we observe more fields with more than 300 individuals (63 educational fields) than for women (56 educational fields).

For presentation purposes we focus on 25 fields out of the 74 fields of education when discussing our results. We selected these fields from vocational and academic education with varying program length in order to represent the characteristics of the full range of fields in the sample. The chosen fields and their characteristics are shown in Table A2.3 and A2.4. The first column of the tables depicts the hourly earnings for men (Table A2.3) and women (Table A2.4). The average hourly earnings by field are not corrected for varying distribution of characteristics over the fields as for example different age structures and different magnitudes of forgone earnings due to more years spent in education. For this uncorrected measure of earnings the fields of dentistry (uni), medicine (uni), industrial engineering (appsc.), management science (appsc.) and finance and insurance (appsc.) rank highest for men. For women the medical fields are followed by university educations in teaching, law and business. As we will see later on, the ranking of fields changes when field specific characteristics as the length of the educational program, the unemployment probability and personal characteristics of the graduates are controlled for.

2.4 Results

The results of the field specific returns are derived from estimating a modified version of the standard Mincer wage regression as described in section 2.2. Table A2.5 gives the coefficients of the regression. The first and third column

[35] Another potential data source would be the German Socio Economic Panel (SOEP), which recently added information on subject of graduation additionally to the already available information on higher educational degrees. The disadvantage of this data set is the smaller sample size, which would only allow us to analyze the most popular fields of education.

gives the estimation results for men and women. Column 5 shows the estimation results for men who graduated from an engineering field. As expected, for all fields, the hourly earnings increase with age at a diminishing rate. The effect of tenure in the current firm is significantly positive for men and women. Furthermore, German nationals tend to have higher hourly earnings and earnings tend to be lower in the eastern part of Germany. Our dependent variable is net earnings because gross earnings are not reported in the dataset. For that reason, the return and risk measure is not free of effects the tax system and social insurance has on net earnings. We include a dummy variable for being married and for working part-time (and the interaction between both) in the wage equation to catch the major tax effects. Married taxpayers in Germany can file a joint tax return which reduces the tax burden and, thus, increases net earnings. The monetary benefit of this joint tax return increases, the higher the income difference of the married couple is. As expected, being married has a positive effect on net earnings for men. For women the effect of being married is not statistically significant. Part-time work can also lead to a lower tax-rate and therefore increased net earnings. The effect of part-time on earnings is positive and significant for both sexes. For women, though, the interaction of being married and working part-time has a strong negative effect on earnings.

The excess returns $(E[\hat{R}_j] - \overline{\hat{R}})$[36] for the selected fields are shown in Table A2.6 and Table A2.7.[37] Columns 1 to 3 give the excess returns when the capital value of each field is not discounted ($\gamma = 1$). Columns 4 to 5 show the values when earnings are discounted with a rate of $\gamma = 1.03$. For men, the university fields of dentistry and medicine yield the highest returns over the life-cycle if earnings are not discounted. The medical fields are followed by an education in industrial engineering (appsc.), business (uni) and computer science (uni). Other than for men, teaching belongs to the "top 5" performing fields for women. The "top 5" fields for women are: Dentistry (uni), medicine (uni), management science (appsc.), teaching (uni) and finance and insurance (appsc.). Dentistry and medicine are clear outliers with an hourly wage that is almost 50 percent higher than the sample average. This result is comparable to the results of Chevalier (2011) who finds a similar pattern for the UK. At the lower end of the distribution of returns are vocational educations, both for

[36]Note that the excess returns for men and women are calculated with respect to the sample average for men and women respectively. The sample average for men is $\overline{\hat{R}} = 45.85$, and for women $\overline{\hat{R}} = 43.41$.

[37]Table A2.12 and A2.13 show the returns for the full set of fields.

men and women. Although graduates from a vocational program forgo fewer earnings early in their life, academic graduates catch up through higher earnings and a steeper wage increase over the life-cycle. The academic education with the lowest returns is social work (uni) for men and construction engineering for women. However, even if most of the academic fields yield comparably high returns, a university education is not in all cases preferable to vocational education in terms of returns. For example, for men an education in vocational training in business yields higher returns as a university education in political science.

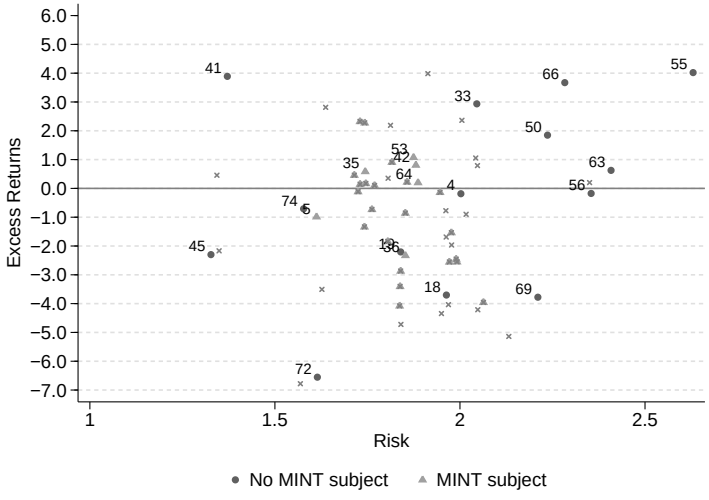
If the capital value of each field is discounted to consider that individuals prefer earnings at an earlier point in time, the ranking of fields changes. In particular fields with a shorter program length, e.g., programs at a university of applied science and in vocational training, become financially more attractive. Graduating in law or computer science from a university, for example, looses rank, while a degree from a university of applied science in management science or business becomes one of the five top-performing fields for men and women.

When calculating the returns to a field of education, we do not consider costs associated with the field except for forgone earnings while in education. Since there were no tuition fees for post-secondary education in Germany for the students observed in our sample, we do not have to account for this type of cost. Still, some fields of education yield high returns mainly for those who become self-employed. As shown in Table A2.3 and A2.4, dentists, medical doctors and legal scientists have the highest share of self-employed and earnings vary widely between the self-employed and employees. For medical doctors and dentists high investment costs are associated with becoming self-employed, i.e. starting their own doctor's office. Hence, it has to be kept in mind that some of the returns to these educations will be the returns to investment into financial capital that the individual had to make earlier. The high returns for management science, teaching and finance and insurance can be assumed to be connected to the civil servant status and the low risk of unemployment of a high proportion of the graduates from these fields. To account for the special status of civil servants and self-employed, we estimate a specification of the Mincer wage regression which adjusts the returns for the employment status. Table A2.8 and A2.9 show that, as expected, the returns to management science and teaching rank lower than in the baseline specification because the specification controls for the effect, civil servant status has on earnings.

2.4.1 Mean-variance plots

In order to evaluate the fields of education as investment goods, we depict our estimation results as mean variance plots in Figure 2.1 for men and Figure 2.2 for women. Returns and risk for each field are plotted against each other. The fields chosen for presentation are labeled. Further, fields belonging to the group of technical subjects (MINT-fields) are marked because they receive special attention in our analysis. As described above, our measures are the discounted capital values of the logarithm earnings over the life-cycle. The expected excess returns are thus defined as the deviation of the discounted capital value of log earnings for each field from the sample mean of the discounted capital value of log earnings over all fields. The sample means of the discounted capital values of log-earnings account to 45.85 Euros for men and 43.41 Euros for women. The risk measure is the standard deviation of capital value of the (log-) earnings within a field. As we conducted separate earnings regression, we also present all parameters separately for men and women.

Figure 2.1: Mean-Variance plot: Men

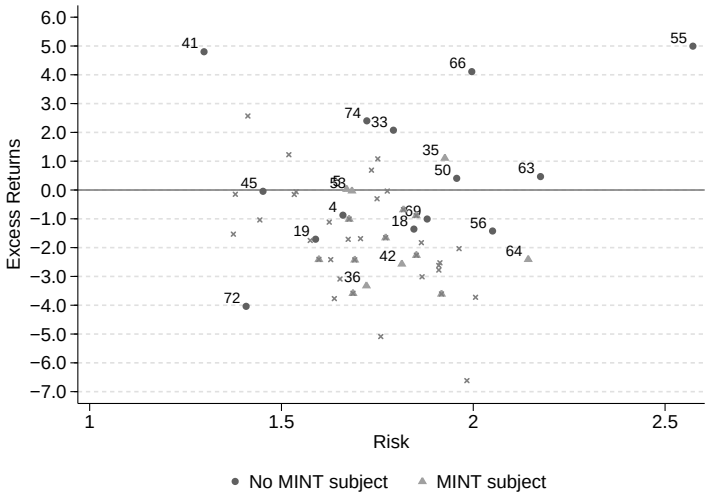


4	Voc:Business
5	Voc:Chemical Engineering
18	Voc:Media
19	Voc:Medical Services
33	AppSc:Business
35	AppSc:Computer Science
36	AppSc:Construction Engineering
41	AppSc:Management Science
42	AppSc:Manufacturing Engineering
45	AppSc:Social Work
50	Uni:Business
53	Uni:Computer Science
55	Uni:Dentistry
56	Uni:Economics
63	Uni:Law
64	Uni:Manufacturing Engineering
66	Uni:Medicine
69	Uni:Political Science
72	Uni:Social Work
74	Uni:Teaching

Notes: Only selected fields are labeled. The remaining fields are depicted as x.

In general, we find that higher levels of education are associated with higher expected returns but also with higher risk. Literature suggests that the variance of earnings is increasing with the level of schooling (see e.g. Levhari and Weiss, 1974; Hartog and Diaz-Serrano, 2007), but this view is not straight forward (Belzil and Leonardi, 2007). Schooling may reduce earnings variation by

Figure 2.2: Mean-Variance plot: Women



4	Voc:Business
5	Voc:Chemical Engineering
18	Voc:Media
19	Voc:Medical Services
33	AppSc:Business
35	AppSc:Computer Science
36	AppSc:Construction Engineering
41	AppSc:Management Science
42	AppSc:Manufacturing Engineering
45	AppSc:Social Work
50	Uni:Business
53	Uni:Computer Science
55	Uni:Dentistry
56	Uni:Economics
63	Uni:Law
64	Uni:Manufacturing Engineering
66	Uni:Medicine
69	Uni:Political Science
72	Uni:Social Work
74	Uni:Teaching

Notes: Only selected fields are labeled. The remaining fields are depicted as x.

reducing the unemployment risk or by raising the job offer probabilities but it may increase wage variation if more educated workers find jobs in sectors of occupations where wages are more volatile. Our estimates take into account the lower unemployment risk at higher education levels as explained in section 2.2. Unemployment is rather low for our sample of individuals with a university entrance degree, hence the probability of unemployment does not contribute a lot to the earnings variation. In addition to the higher risk at higher education levels, we find that the different fields also show a high heterogeneity with respect to risk and returns within an education level, which is disregarded, when only comparing different levels of education.

The graph also shows the importance of taking risk into account. Simply comparing the returns for men for e.g. management science (appsc.) with business (appsc.) would yield no difference because the monetary return over the life-cycle is relatively close. But the average returns for business exhibit a much higher risk level, such that this field is more unattractive than management science in terms of an investment good.

Fields belonging to the group of technical fields receive special attention because of the controversially discussed shortage of graduates from these fields of education in Germany. The mean-variance plots show the efficiency of one field compared to another. Following standard economic theory of demand and

supply, prices for graduates from fields with a shortage of graduates should be high, i.e. we should observe high earnings and a low level of earnings risk. Our results do not suggest that there is a shortage of skilled labor in these subjects since we do not observe high prices for graduates from technical fields compared to other fields. Other fields, especially from the group of social science fields are still more attractive investments. However, our model is not suited to predict a possible shortage in the (near) future, as we are only able to use retrospective data.

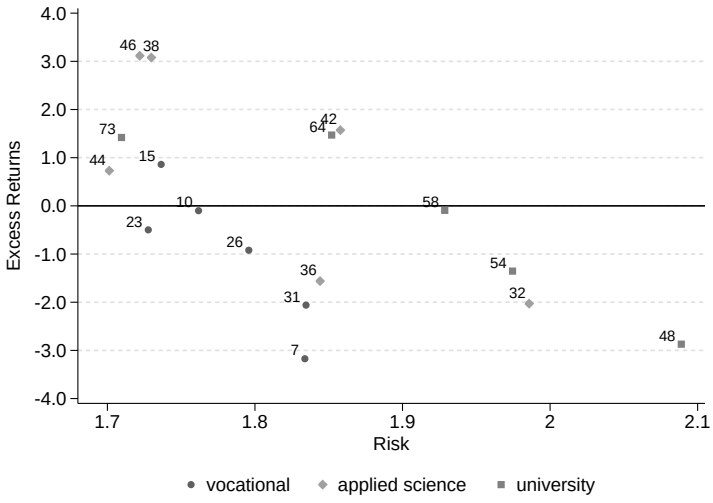
2.4.2 Technical abilities

To reduce the role of potential ability bias, we compare the properties of human capital returns within a group of fields. Individuals who revealed a preference for a engineering field of education are likely to be similar with respect to their educational preferences and abilities. Figure 2.3 shows the mean-variance plot for all engineering educations for men.[38] The sample average mean of the discounted capital value of log-earnings for men who graduated from a technical field is 44.88 Euro. For the technical fields risk seems to decrease with returns. On the one hand, the highest paying fields supply engineering and electrical engineering (appsc.) have a very low risk level. On the other hand, students who graduate from architecture can expect only low returns at a high level of risk. When comparing earnings within a certain group of fields, we observe that the discounted life-time log-earnings with a vocational degree are often not much lower than with a university degree. Manufacturing engineering at a university yields about the same returns over the life-cycle as a vocational degree in the same field. Further, the earnings risk is to some extend lower when graduating from vocational training. In contrast, graduating from a university of applied science with a degree in electrical engineering is preferable to a vocational training degree in the same field. Hence, university education is not always the choice with the highest investment value.

The results show that the field of education is as interesting as the level of education when assessing human capital investments. A student interested in a university of applied science education in a technical field should, for example, prefer manufacturing engineering over construction engineering because it yields a higher return at the same level of risk.

[38] Returns and risk measures are estimated based on a sample of 37,385 male graduates from MINT-fields. Results for women are available from the authors upon request.

Figure 2.3: Mean-Variance plot: Engineering fields, Men



7	Voc:Construction Engineering
10	Voc:Electrical Engineering
15	Voc:Manufacturing Engineering
23	Voc:Precision Engineering
26	Voc:Supply Engineering
31	Voc:Transport Engineering
32	AppSc:Architecture
36	AppSc:Construction Engineering
38	AppSc:Electrical Engineering
42	AppSc:Manufacturing Engineering
44	AppSc:Precision Engineering
46	AppSc:Supply Engineering
48	Uni:Architecture
54	Uni:Construction Engineering
58	Uni:Electrical Engineering
64	Uni:Manufacturing Engineering
73	Uni:Supply Engineering

2.4.3 Standardized return measure

In order to further assess the risk-return trade-off, we apply the standardized return measure. The standardized return measure gives us the returns per standard deviation of the unexplained part of the returns. Table A2.10 for men and Table A2.11 for women rank the educations from the highest standardized return to the lowest. As for the unstandardized returns the top-performing fields consist of programs at the university and university of applied science. The ranking of the fields, thus, changes. Fields with a low earnings risk move up in the ranking. It is not surprising that management science performs better when earnings risk is taken into account. Around 80 percent of graduates from the field of management science are employed as civil servants. A career as a civil servant traditionally is connected to low earnings risk and low risk of unemployment. For men, social work at university and university of applied science belong to the low performing fields while for women construction engineering belongs to the worst 5 educations. Also, teaching ranks only 35^{th} for men, while it is one of the top-performing fields for women. Similarly, medical services is at the very bottom of the ranking for men, while it is one of the top performing vocational educations for women.[39]

The differences in the performance of fields between men and women might explain some of the wide differences of educational choices for men and women. As it is often discussed (see e.g. Machin and Puhani, 2003; Zafar, 2009) women

[39]Table A2.12 and A2.13 show the standardized returns for the full set of fields.

are assumed to choose fields in humanities, language, education and creative arts etc., because it relates to the "traditional" female work environments. Our findings suggest that their choices can also be linked to "rational" investment choices.

2.5 Conclusion

In our paper, we analyze the risk and return properties of approximately 70 different educational fields. While there is a broad literature analyzing the returns to different educational levels, little research examines at returns to education at a more disaggregated level. Results suggest that the financial performance of different educations does not only vary across qualification levels but does also vary strongly within a qualification level. Further, the financial attractiveness of fields varies by gender.

We use the German Micro Census for the years 2005 to 2009 to estimate field specific returns by extending the Mincer wage equation controlling for different fields of education. We then use our estimation results to calculate an average measure of log hourly income over the life-cycle, as well as field specific earnings risk. Applying general models from the financial asset theory to our estimation results allows us to evaluate the fields of education in terms of their efficiency as investment goods.

In general, higher educational levels yield higher expected returns, but are also associated with greater variance. In addition, we show that beyond the general tendency across educational levels, there is heterogeneity within educational levels that should not be neglected. In this regard, graduating in business from a university yields higher expected returns than majoring in business at a university of applied science (between educational levels), it also yields higher returns than majoring in maths at a university (within educational level). Furthermore, we show that risk is a source that should not be neglected. Even though graduates in management science (university of applied science) earn on average the same as graduates in business (university level), the latter is associated with a higher risk which makes it an inefficient investment choice over management science.

The findings are in particular helpful in terms of analyzing shortages of skilled labor in certain fields of education, as well as finding instruments to solve this possible problem. A shortage of skilled labor should be reflected in high returns and a relatively low risk associated with the education that exhibits

the shortage. In Germany, a controversially-discussed topic is the shortage of skilled labor in the MINT-subjects. Our results however do not suggest that there is a shortage of skilled labor in these subjects, at least not in the time of our analysis. However, our model is not suited to predict a possible shortage in the (near) future, as we are only able to use retrospective data.

Even though we are using a rich dataset, there are several problems we could not address in our study. Thus, it remains for future studies to determine possible biases resulting from ability sorting or endogeneity of educational fields when estimating field specific returns. Another extension of our study would be to incorporate our findings into an educational decision process. But so far, there is no extensive dataset available (for Germany) that would allow us to model the field an individual chooses while controlling for the individuals socio-economic background as well as the expected returns and the associated risk.

2.6 Appendix

2.6.A Tables and figures

Table A2.1: Income groups: Mean

Income group Micro Census	Mean SOEP
(1)	(2)
<150	52
150 - 300	231
300 - 500	404
500 - 700	620
700 - 900	818
900 - 1100	1023
1100 - 1300	1227
1300 - 1500	1437
1500 - 1700	1627
1700 - 2000	1884
2000 - 2300	2171
2300 - 2600	2475
2600 - 2900	2777
2900 - 3200	3065
3200 - 3600	3438
3600 - 4000	3865
4000 - 4500	4284
4500 - 5000	4836
5000 - 5500	5280
5500 - 6000	5864
6000 - 7500	6764
7500 - 10000	9005
10000- 18000	12886
>18000	21778
Number of observations	15,887

Notes: The means of each income group from the Micro Census are calculated based on a sample of 15,887 individuals from the German Socio-Economic Panel.

Table A2.2: Sample descriptives

	Men		Women	
	Mean	Std. Dev.	Mean	Std. Dev.
	(1)	(2)	(3)	(4)
Net hourly earnings (Euro)	16.43	11.20	12.29	7.53
Age (years)	43.41	10.12	40.38	10.17
Education (years)	17.33	1.52	17.10	1.50
Tenure (years)	10.49	9.67	8.99	8.95
Unemployment (percent)	4.54%		5.72%	
German (percent)	89.21%		88.30%	
Married (percent)	62.06%		49.73%	
Region (percent)				
North	24.71%		23.65%	
Middle	35.67%		37.20%	
East	22.51%		19.61%	
South	17.11%		19.54%	
Year (percent)				
2005	18.87%		17.82%	
2006	19.93%		19.47%	
2007	19.93%		19.64%	
2008	20.43%		20.92%	
2009	20.84%		22.15%	
Number of observations	126,314		89,496	

Source: Numbers based on German Micro Census, years 2005-2009.

Table A2.3: Characteristics: Selected fields of education, men

	Hourly earnings (Euro)	Share of unempl. (%)	Length of education (years)	Share of students within degree (%)	Share of self-employed (%)	Share of civil servants (%)
	(1)	(2)	(3)	(4)	(5)	(6)
Uni:Dentistry	26.56	2.24%	6	1.12%	88.00%	1.04%
Uni:Medicine	23.64	1.30%	6	5.73%	40.42%	3.36%
Uni:Business	21.16	3.68%	6	7.60%	19.61%	4.82%
Uni:Law	20.58	3.28%	6	5.26%	34.51%	23.92%
Uni:Economics	19.67	5.27%	6	1.69%	19.44%	8.26%
Uni:Manufacturing Engin.	18.57	3.19%	6	3.37%	10.23%	5.68%
Uni:Computer Science	17.67	3.49%	6	2.95%	13.36%	2.77%
AppSc:Business	17.43	3.44%	4	6.31%	16.57%	4.49%
AppSc:Industrial Engin.	17.41	3.30%	4	1.28%	10.53%	2.22%
AppSc:Manufacturing Engin.	17.32	3.76%	5	4.94%	10.82%	2.64%
AppSc:Finance and Insurance	17.31	0.81%	4	1.27%	8.70%	55.49%
Uni:Teaching	16.95	2.48%	5	7.30%	3.75%	70.05%
AppSc:Management Science	16.59	0.78%	3	3.98%	1.39%	82.69%
AppSc:Computer Science	15.61	4.21%	5	2.58%	10.85%	1.85%
Uni:Political Science	15.15	7.32%	6	0.72%	21.27%	8.06%
AppSc:Construction Engin.	14.86	6.41%	5	3.21%	22.51%	5.28%
Voc:Business	13.77	7.50%	3	7.98%	12.85%	1.98%
Uni:Social Work	13.62	7.36%	6	0.45%	9.56%	10.38%
AppSc:Social Work	13.01	3.36%	4	1.74%	7.23%	7.23%
Voc:Chemical Engin.	12.55	7.08%	3	1.67%	6.13%	2.15%
Voc:Medical Services	11.58	4.48%	3	2.98%	29.04%	1.35%
Voc:Construction Engin.	11.23	10.16%	3	5.69%	26.50%	2.56%
Voc:Hotel Restaurant	11.19	13.00%	3	1.60%	18.38%	0.55%
Voc:Media	10.96	10.30%	3	2.64%	30.97%	0.43%
Voc:Gardening	9.44	8.05%	3	0.83%	31.21%	0.34%

Source: Numbers based on German Micro Census, years 2005-2009.

Table A2.4: Characteristics: Selected fields of education, women

	Hourly earnings (Euro)	Share of unempl. (%)	Length of education (years)	Share of students within degree (%)	Share of self-employed (%)	Share of civil servants (%)
	(1)	(2)	(3)	(4)	(5)	(6)
Uni:Dentistry	20.65	3.94%	6	1.33%	77.69%	0.61%
Uni:Medicine	17.70	4.33%	6	7.24%	31.38%	2.36%
Uni:Teaching	15.18	2.60%	5	22.47%	2.59%	68.48%
Uni:Law	15.09	5.22%	6	5.51%	22.67%	25.84%
Uni:Business	14.00	6.33%	6	6.61%	10.18%	4.15%
Uni:Economics	13.73	7.69%	6	1.70%	10.95%	6.84%
AppSc:Computer Science	13.58	10.05%	5	0.76%	5.43%	0.86%
Uni:Computer Science	13.28	5.37%	6	0.83%	8.40%	2.47%
AppSc:Management Science	13.25	1.05%	3	4.82%	0.65%	76.81%
Uni:Manufacturing Engin.	13.23	7.08%	6	0.69%	8.23%	3.66%
AppSc:Finance and Insurance	13.03	1.09%	4	1.43%	3.17%	60.33%
Uni:Political Science	13.02	9.78%	6	0.72%	15.62%	6.01%
AppSc:Business	12.34	5.07%	4	7.30%	7.66%	3.96%
AppSc:Social Work	11.65	4.85%	4	6.22%	6.53%	5.68%
Uni:Social Work	11.47	7.18%	6	1.79%	7.14%	6.21%
AppSc:Manufacturing Engin.	11.11	9.92%	5	0.76%	9.60%	1.98%
AppSc:Construction Engin.	10.90	12.34%	5	1.37%	11.65%	5.66%
Voc:Chemical Engin.	10.55	6.33%	3	1.62%	4.33%	0.87%
Voc:Personal Services	10.25	10.77%	3	0.95%	8.31%	9.85%
Voc:Business	10.06	8.69%	3	12.90%	5.66%	0.91%
Voc:Media	9.98	10.29%	3	1.96%	20.30%	0.30%
Voc:Medical Services	9.57	5.92%	3	12.02%	11.89%	0.53%
Voc:Textile	8.99	14.72%	3	0.94%	17.48%	1.29%
Voc:Dentistry	8.72	6.46%	3	1.26%	7.32%	0.22%
Voc:Beauty	8.00	13.12%	3	1.22%	32.59%	0.49%

Source: Numbers based on German Micro Census, years 2005-2009.

Table A2.5: Mincer wage regression: Men, women and technical fields

	Men		Women		Engineering fields (men)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
	(1)	(2)	(3)	(4)	(5)	(6)
Age X Voc. Educ.	0.04***	0.003	0.044***	0.004	0.044***	0.002
Age X Uni. of AppSc.	0.047***	0.003	0.040***	0.005	0.044***	0.010
Age X University	0.070***	0.006	0.068***	0.007	0.061***	0.006
Age^2Xvoc	-0.000***	0.000	-0.000***	0.000	-0.000***	0.000
Age^2Xappsc	-0.001***	0.000	-0.000***	0.000	-0.001***	0.000
Age^2Xuni	-0.001***	0.000	-0.001***	0.000	-0.001***	0.000
German	0.121***	0.010	0.112***	0.017	0.140***	0.011
Married	0.210***	0.005	0.006	0.006	0.192***	0.007
Part-time work	0.117***	0.024	0.236***	0.020	-0.009	0.034
Married X Part-time	-0.036*	0.018	-0.194***	0.015	-0.031	0.027
Tenure	0.013***	0.001	0.015***	0.001	0.014***	0.001
$Tenure^2$	-0.000***	0.000	-0.000***	0.000	-0.000***	0.000
University of Applied Science:						
Architecture	1.171***	0.072	1.263***	0.091	1.258***	0.067
Business	1.348***	0.070	1.379***	0.090	.	.
Chemical Engin.	1.344***	0.071	.	.	.	.
Computer Science	1.330***	0.068	1.462***	0.091	.	.
Construction Engin.	1.202***	0.073	1.252***	0.088	1.300***	0.068
Educational Science	.	.	1.232***	0.085	.	.
Electrical Engin.	1.326***	0.072	.	.	1.415***	0.067
Finance and Insurance	1.319***	0.070	1.370***	0.088	.	.
Industrial Engin.	1.397***	0.069	.	.	.	.
Management Science	1.282***	0.070	1.388***	0.089	.	.
Manufacturing Engin.	1.338***	0.072	1.272***	0.089	1.430***	0.067
Maths	1.275***	0.072	1.283***	0.088	.	.
Precision Engin.	1.303***	0.072	.	.	1.396***	0.068
Social Work	1.096***	0.073	1.274***	0.087	.	.
Supply Engin.	1.327***	0.072	.	.	1.415***	0.067
University						
Anglistic	0.685***	0.143	0.681***	0.155	.	.
Architecture	0.592***	0.145	0.625***	0.153	1.264***	0.180
Biology	0.664***	0.142	0.706***	0.153	.	.
Business	0.875***	0.141	0.805***	0.151	.	.
Chemical Engin.	0.746***	0.145	0.717***	0.155	.	.
Chemistry	0.800***	0.145	0.752***	0.156	.	.
Computer Science	0.833***	0.138	0.774***	0.154	.	.
Construction Engin.	0.660***	0.144	0.626***	0.155	1.335***	0.180
Dentistry	0.975***	0.146	1.025***	0.155	.	.
Economics	0.783***	0.145	0.720***	0.157	.	.
Educational Science	0.594***	0.147	0.680***	0.157	.	.
Electrical Engin.	0.712***	0.145	.	.	1.391***	0.179
Geo Science	0.616***	0.144	0.670***	0.153	.	.
German Literature	0.577***	0.146	0.683***	0.155	.	.
History	0.585***	0.144	0.679***	0.155	.	.
Industrial Engin.	0.840***	0.141	.	.	.	.
Law	0.807***	0.143	0.798***	0.153	.	.
Manufacturing Engin.	0.784***	0.144	0.662***	0.157	1.457***	0.181
Maths	0.774***	0.145	0.755***	0.156	.	.
Medicine	0.947***	0.145	0.982***	0.155	.	.
Music	0.519***	0.145	0.586***	0.156	.	.
Physics	0.796***	0.144	.	.	.	.
Political Science	0.611***	0.142	0.760***	0.151	.	.
Psychology	0.735***	0.146	0.785***	0.155	.	.
Regional Science	0.586***	0.145	0.653***	0.154	.	.
Social Work	0.464***	0.147	0.576***	0.156	.	.
Supply Engin.	0.784***	0.144	.	.	1.453***	0.182
Teaching	0.645***	0.147	0.788***	0.156	.	.
Vocational Education						
Accounting	1.196***	0.070	1.117***	0.059	.	.
Anglistic	.	.	1.196***	0.061	.	.
Beauty	.	.	0.871***	0.059	.	.
Business	1.170***	0.070	1.111***	0.060	.	.
Chemical Engin.	1.129***	0.070	1.135***	0.060	.	.

Continued on next page

	Men		Women		Technical fields (men)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
	(1)	(2)	(3)	(4)	(5)	(6)
Computer Science	1.202***	0.067	.	.	.	.
Construction Engin.	1.008***	0.071	.	.	1.155***	0.097
Dentistry	.	.	0.959***	0.060	.	.
Educational Science	.	.	1.059***	0.059	.	.
Electrical Engin.	1.130***	0.070	.	.	1.264***	0.097
Finance and Insurance	1.246***	0.069	1.171***	0.059	.	.
Gardening	0.865***	0.071	.	.	.	.
Hotel Restaurant	1.023***	0.070	1.027***	0.060	.	.
Management Science	1.177***	0.069	1.123***	0.059	.	.
Manufacturing Engin.	1.170***	0.071	1.111***	0.061	1.314***	0.097
Marketing	.	.	1.164***	0.060	.	.
Maths	1.286***	0.071	.	.	.	.
Media	1.027***	0.069	1.101***	0.060	.	.
Medical Services	1.052***	0.070	1.051***	0.058	.	.
Nursing	1.054***	0.071	1.111***	0.059	.	.
Office Assistant	.	.	1.040***	0.059	.	.
Personal Services	.	.	1.026***	0.060	.	.
Precision Engin.	1.108***	0.071	.	.	1.253***	0.097
Public Security	1.165***	0.070	.	.	.	.
Social Work	.	.	1.094***	0.059	.	.
Supply Engin.	1.080***	0.071	.	.	1.228***	0.097
Textile	.	.	0.955***	0.062	.	.
Tourism	.	.	1.057***	0.059	.	.
Trade and Logistic	1.102***	0.069	1.065***	0.059	.	.
Transport	1.181***	0.070	1.136***	0.060	.	.
Transport Engin.	1.051***	0.071	.	.	1.194***	0.097
Year dummies	yes		yes		yes	
Region dummies	yes		yes		yes	
N	120,441		84,261		39,522	

Source: Estimation based on German Micro Census, years 2005-2009.

Table A2.6: Returns to field of education: Men

	Rank	Return $E[\hat{R}_j] - \overline{\hat{R}}$	S.E.	Rank	Return $E[\hat{R}_j] - \overline{\hat{R}}$	S.E.
	(1)	(2)	(3)	(4)	(5)	(6)
Uni:Dentistry	1	10.941***	0.609	1	4.020***	0.337
Uni:Medicine	2	10.226***	0.552	4	3.672***	0.313
AppSc:Industrial Engin.	3	6.600***	0.646	2	3.984***	0.269
Uni:Business	4	6.447***	0.519	11	1.848***	0.265
Uni:Computer Science	5	4.854***	0.504	12	1.077***	0.234
AppSc:Management Science	7	4.804***	0.687	3	3.890***	0.308
AppSc:Business	8	4.509***	0.629	5	2.936***	0.268
AppSc:Finance and Insurance	9	4.272***	0.685	6	2.815***	0.298
Uni:Law	10	3.924***	0.563	17	0.626***	0.302
Uni:Manufacturing Engin.	14	3.045***	0.529	24	0.201	0.294
Uni:Economics	18	2.260***	0.567	30	-0.175	0.315
AppSc:Manufacturing Engineerin	21	1.810***	0.528	15	0.809***	0.239
AppSc:Computer Science	23	1.357	0.700	18	0.586*	0.281
Uni:Teaching	27	-0.252	0.721	32	-0.708	0.407
Voc:Business	39	-3.052***	0.647	31	-0.185	0.286
AppSc:Construction Engin.	42	-4.562***	0.521	46	-2.328***	0.245
Voc:Chemical Engin.	44	-4.621***	0.659	37	-0.986***	0.292
Uni:Political Science	46	-5.192***	0.529	54	-3.777***	0.280
AppSc:Social Work	50	-5.931***	0.682	45	-2.299***	0.325
Voc:Medical Services	55	-7.003***	0.697	44	-2.205***	0.316
Voc:Media	59	-9.951***	0.671	53	-3.702***	0.297
Voc:Construction Engin.	60	-10.690***	0.567	57	-4.079***	0.259
Uni:Social Work	61	-10.929***	0.697	62	-6.554***	0.374
Voc:Hotel Restaurant	62	-10.957***	0.561	58	-4.212***	0.242
Voc:Gardening	63	-15.977***	0.633	63	-6.781***	0.287
Total number of fields	63			63		

S.E. calculated using the delta method. Significance levels: * : 10% ** : 5% * : 1%

Source: Estimation based on German Micro Census, years 2005-2009.

Notes: Columns 1 to 3 give the excess returns when the capital value of each field is not discounted ($\gamma = 1$). Columns 4 to 5 show the values when log-earnings are discounted with a rate of $\gamma = 1.03$. Only selected fields are depicted. A full list of field is given in A2.12.

Table A2.7: Returns to field of education: Women

	$\gamma = 1$			$\gamma = 1.03$		
	Rank	Return $E[\hat{R}_j] - \overline{\hat{R}}$	S.E.	Rank	Return $E[\hat{R}_j] - \overline{\hat{R}}$	S.E.
	(1)	(2)	(3)	(4)	(5)	(6)
Uni:Dentistry	1	13.206***	0.842	1	4.994***	0.408
Uni:Medicine	2	11.377***	0.858	3	4.110***	0.413
AppSc:Management Science	3	7.220***	1.195	2	4.800***	0.560
Uni:Teaching	4	6.370***	1.102	5	2.401***	0.540
AppSc:Finance and Insurance	5	4.366***	1.184	4	2.570***	0.548
Uni:Law	6	3.846***	0.932	11	0.466	0.436
Uni:Business	7	3.718***	0.867	12	0.405	0.402
AppSc:Business	8	3.380***	0.981	6	2.076***	0.439
AppSc:Computer Science	9	2.950***	0.885	8	1.108**	0.387
Uni:Computer Science	10	2.824***	0.855	14	-0.028	0.404
Uni:Political Science	14	0.791	0.853	24	-1.007*	0.397
Uni:Economics	16	-0.063	0.867	29	-1.423***	0.423
AppSc:Social Work	21	-0.850	1.096	16	-0.045	0.522
Uni:Manufacturing Engin.	25	-2.096*	0.816	39	-2.407***	0.401
Voc:Chemical Engin.	27	-2.142*	0.961	13	0.027	0.478
Voc:Business	35	-3.908***	0.960	22	-0.874	0.476
AppSc:Manufacturing Engin.	40	-4.511***	0.762	44	-2.567***	0.357
Voc:Media	44	-4.855***	0.935	28	-1.357**	0.464
Uni:Social Work	46	-5.465***	1.091	54	-4.038***	0.522
Voc:Medical Services	47	-5.540***	1.082	33	-1.708**	0.541
AppSc:Construction Engin.	50	-6.047***	0.807	49	-3.323***	0.382
Voc:Hotel Restaurant	52	-7.639***	0.890	46	-2.778***	0.441
Voc:Personal Services	53	-8.099***	1.056	47	-3.012***	0.531
Voc:Dentistry	54	-9.579***	1.002	53	-3.769***	0.499
Voc:Textile	55	-12.167***	0.837	55	-5.087***	0.416
Voc:Beauty	56	-15.164***	0.924	56	-6.617***	0.459
Total number of fields	56			56		

S.E. calculated using the delta method. Significance levels: * : 10% ** : 5% * : 1%

Source: Estimation based on German Micro Census, years 2005-2009.

Notes: Columns 1 to 3 give the excess returns when the capital value of each field is not discounted ($\gamma = 1$). Columns 4 to 5 show the values when log-earnings are discounted with a rate of $\gamma = 1.03$. Only selected fields are depicted. A full list of field is given in Table A2.13.

Table A2.8: Returns to field of education: Controlling for work-status, men

	Rank	Return $E[\hat{R}_j] - \overline{\hat{R}}$	S.E.
	(1)	(2)	(3)
Uni:Dentistry	1	5.244***	0.365
Uni:Medicine	2	4.141***	0.314
AppSc:Industrial Engin.	3	4.128***	0.244
AppSc:Business	4	3.140***	0.243
Voc:Maths	5	2.484***	0.241
AppSc:Management Science	8	2.296***	0.518
Uni:Business	10	2.023***	0.251
AppSc:Finance and Insurance	11	1.955***	0.397
Uni:Computer Science	12	1.200***	0.211
AppSc:Manufacturing Engin.	16	0.933**	0.216
AppSc:Computer Science	17	0.744**	0.259
Uni:Law	18	0.655*	0.323
Voc:Business	26	0.024	0.255
Uni:Economics	29	-0.089	0.311
Voc:Chemical Engin.	34	-0.880***	0.264
Voc:Medical Services	41	-1.779***	0.276
Uni:Teaching	42	-2.004***	0.558
AppSc:Construction Engin.	43	-2.110***	0.228
AppSc:Social Work	47	-2.343***	0.301
Uni:Political Science	54	-3.683***	0.274
Uni:German Literature	59	-4.377***	0.383
Uni:Music	60	-4.854***	0.344
Uni:History	61	-4.897***	0.327
Voc:Gardening	62	-6.301***	0.252
Uni:Social Work	63	-6.653***	0.372
Total number of fields	63		

S.E. calculated using the delta method. Significance levels: * : 10% ** : 5% * : 1%

Source: Estimation based on German Micro Census, years 2005-2009.

Notes: Excess returns are calculated using a discount rate of ($\gamma = 1.03$). The additional control variables in the wage equation are indicator variables for self-employment and civil service status. Only selected fields are depicted.

Table A2.9: Returns to field of education: Controlling for work-status, women

	Rank	Return $E[\hat{R}_j] - \overline{\hat{R}}$	S.E.
	(1)	(2)	(3)
Uni:Dentistry	1	5.769***	0.372
Uni:Medicine	2	4.672***	0.286
AppSc:Business	3	2.626***	0.296
Voc:Finance and Insurance	4	2.033***	0.347
AppSc:Management Science	5	1.948***	0.565
AppSc:Computer Science	7	1.726***	0.263
Uni:Business	9	0.876***	0.251
Voc:Chemical Engin.	10	0.762*	0.308
AppSc:Finance and Insurance	11	0.674	0.497
Uni:Computer Science	15	0.499	0.267
AppSc:Social Work	16	0.449	0.347
Uni:Teaching	19	0.100	0.569
Uni:Law	20	0.055	0.318
Voc:Business	21	-0.180	0.307
Uni:Political Science	26	-0.640*	0.258
Voc:Medical Services	29	-0.986**	0.354
Uni:Economics	33	-1.120***	0.329
AppSc:Manufacturing Engin.	40	-2.031***	0.250
Voc:Personal Services	47	-2.765***	0.375
AppSc:Construction Engin.	49	-2.938***	0.270
Voc:Dentistry	50	-3.054***	0.327
Uni:Social Work	54	-3.634***	0.371
Voc:Textile	55	-4.495***	0.288
Voc:Beauty	56	-5.981***	0.325
Total number of fields	56		

S.E. calculated using the delta method. Significance levels: * : 10% ** : 5% * : 1%

Source: Estimation based on German Micro Census, years 2005-2009.

Notes: Excess returns are calculated using a discount rate of ($\gamma = 1.03$). The additional control variables in the wage equation are indicator variables for self-employment and civil service status. Only selected fields are depicted.

Table A2.10: Standardized Returns: Men

	Rank	Standardized Return Sj	S.E.
	(1)	(2)	(3)
AppSc:Management Science	1	2.836***	0.225
AppSc:Industrial Engin.	2	2.082***	0.140
AppSc:Finance and Insurance	3	1.719***	0.182
Uni:Medicine	4	1.608***	0.137
Uni:Dentistry	5	1.529***	0.128
AppSc:Business	6	1.435***	0.131
Uni:Business	11	0.826***	0.119
Uni:Computer Science	12	0.574***	0.125
AppSc:Manufacturing Engin.	15	0.430***	0.127
AppSc:Computer Science	18	0.336***	0.161
Uni:Law	20	0.260***	0.125
Uni:Economics	30	-0.074	0.134
Voc:Business	31	-0.092	0.143
Uni:Teaching	35	-0.449	0.258
Voc:Chemical Engin.	37	-0.612***	0.181
Voc:Medical Services	43	-1.199***	0.172
AppSc:Construction Engin.	45	-1.257***	0.132
Uni:Political Science	50	-1.709***	0.127
AppSc:Social Work	51	-1.732***	0.245
Uni:Regional Science	59	-2.228***	0.169
Uni:Music	60	-2.411***	0.165
Uni:History	61	-2.566***	0.167
Uni:Social Work	62	-4.059***	0.232
Voc:Gardening	63	-4.323***	0.183
Total number of fields	63		

S.E. calculated using the delta method. Significance levels: * : 10% ** : 5% * : 1%

Source: Estimation based on German Micro Census, years 2005-2009.

Notes: Excess returns and risk are calculated using a discount rate of ($\gamma = 1.03$). Only selected fields are depicted. A full list of field is given in Table A2.12.

Table A2.11: Standardized Returns: Women

	Rank	Standardized Return Sj	S.E.
	(1)	(2)	(3)
AppSc:Management Science	1	3.697***	0.431
Uni:Medicine	2	2.059***	0.207
Uni:Dentistry	3	1.941***	0.158
AppSc:Finance and Insurance	4	1.819***	0.388
Uni:Teaching	5	1.394***	0.313
AppSc:Business	6	1.159***	0.245
AppSc:Computer Science	9	0.576**	0.201
Uni:Law	11	0.214	0.201
Uni:Business	12	0.207	0.205
Voc:Chemical Engin.	13	0.016	0.286
Uni:Computer Science	14	-0.017	0.240
AppSc:Social Work	16	-0.031	0.360
Voc:Business	23	-0.526	0.287
Uni:Political Science	24	-0.536***	0.211
Uni:Economics	27	-0.694***	0.206
Voc:Medical Services	35	-1.075**	0.340
AppSc:Manufacturing Engin.	42	-1.415***	0.197
Voc:Personal Services	47	-1.614***	0.285
AppSc:Construction Engin.	51	-1.930***	0.222
Voc:Dentistry	53	-2.301***	0.304
Uni:Social Work	54	-2.868***	0.371
Voc:Textile	55	-2.892***	0.237
Voc:Beauty	56	-3.336***	0.232
Total number of fields	56		

S.E. calculated using the delta method. Significance levels: * : 10% ** : 5% * : 1%

Source: Estimation based on German Micro Census, years 2005-2009.

Notes: Excess returns and risk are calculated using a discount rate of $\gamma = 1.03$. Only selected fields are depicted. A full list of fields is given in Table A2.13.

Table A2.12: Returns and standardized Returns to field of education: All fields, men

	Returns $E[\hat{R}_j] - \overline{\hat{R}}$			Standardized Returns Sj		
	Rank	Return	S.E.	Rank	Return	S.E.
Uni:Dentistry	1	4.020***	0.337	5	1.529***	0.337
AppSc:Industrial Engin.	2	3.984***	0.269	2	2.082***	0.269
AppSc:Management Science	3	3.890***	0.308	1	2.836***	0.308
Uni:Medicine	4	3.672***	0.313	4	1.608***	0.313
AppSc:Business	5	2.936***	0.268	6	1.435***	0.268
AppSc:Finance and Insurance	6	2.815***	0.298	3	1.719***	0.298
Voc:Maths	7	2.363***	0.270	10	1.179***	0.270
AppSc:Supply Engin.	8	2.323***	0.256	7	1.343***	0.256
AppSc:Electrical Engin.	9	2.275***	0.252	8	1.305***	0.252
Voc:Finance and Insurance	10	2.189***	0.314	9	1.208***	0.314
Uni:Business	11	1.848***	0.265	11	0.826**	0.265
Uni:Computer Science	12	1.077***	0.234	12	0.574*	0.234
Uni:Industrial Engin.	13	1.055***	0.262	13	0.517*	0.262
AppSc:Chemical Engin.	14	0.909***	0.252	14	0.501*	0.252
AppSc:Manufacturing Engin.	15	0.809***	0.239	15	0.430	0.239
Voc:Accounting	16	0.792**	0.282	16	0.387	0.282
Uni:Law	17	0.626*	0.302	20	0.260	0.302
AppSc:Computer Science	18	0.586*	0.281	18	0.336	0.281
Voc:Computer Science	19	0.459	0.319	19	0.267	0.319
Voc:Public Security	20	0.458	0.312	17	0.341	0.312
Voc:Management Science	21	0.353	0.303	21	0.196	0.303
Uni:Chemistry	22	0.219	0.308	22	0.118	0.308
Voc:Transport	23	0.202	0.280	25	0.086	0.280
Uni:Manufacturing Engin.	24	0.201	0.294	23	0.106	0.294
Voc:Manufacturing Engin.	25	0.170	0.263	24	0.098	0.263
Uni:Supply Engin.	26	0.144	0.292	26	0.083	0.292
Uni:Physics	27	0.102	0.291	27	0.058	0.291
AppSc:Precision Engin.	28	-0.113	0.238	28	-0.065	0.238
Uni:Maths	29	-0.138	0.303	29	-0.071	0.303
Uni:Economics	30	-0.175	0.315	30	-0.074	0.315
Voc:Business	31	-0.185	0.286	31	-0.092	0.286
Uni:Teaching	32	-0.708	0.407	35	-0.449	0.407
Voc:Electrical Engin.	33	-0.730*	0.285	33	-0.414	0.285
AppSc:Maths	34	-0.774**	0.240	32	-0.395	0.240
Uni:Chemical Engin.	35	-0.857**	0.305	36	-0.462	0.305
Uni:Psychology	36	-0.898*	0.362	34	-0.445	0.362
Voc:Chemical Engin.	37	-0.986***	0.292	37	-0.612*	0.292
Voc:Precision Engin.	38	-1.336***	0.258	38	-0.767**	0.258
Uni:Electrical Engin.	39	-1.536***	0.289	39	-0.777**	0.289
Voc:Trade and Logistic	40	-1.688***	0.294	40	-0.860**	0.294
Voc:Supply Engin.	41	-1.841***	0.264	42	-1.020***	0.264
Uni:Anglistic	42	-1.965***	0.288	41	-0.994***	0.288
Voc:Nursing	43	-2.167***	0.309	49	-1.606***	0.309
Voc:Medical Services	44	-2.205***	0.316	43	-1.199***	0.316
AppSc:Social Work	45	-2.299***	0.325	51	-1.732***	0.325
AppSc:Construction Engin.	46	-2.328***	0.245	45	-1.257***	0.245
Uni:Biology	47	-2.456***	0.275	44	-1.235***	0.275
Uni:Construction Engin.	48	-2.549***	0.298	46	-1.280***	0.298
AppSc:Architecture	49	-2.555***	0.255	47	-1.296***	0.255
Voc:Transport Engin.	50	-2.869***	0.256	48	-1.560***	0.256
Uni:Geo Science	51	-3.404***	0.307	52	-1.852***	0.307
Uni:Educational Science	52	-3.505***	0.371	57	-2.154***	0.371
Voc:Media	53	-3.702***	0.297	53	-1.886***	0.297
Uni:Political Science	54	-3.777***	0.280	50	-1.709***	0.280
Uni:Architecture	55	-3.957***	0.308	54	-1.918***	0.308
Uni:German Literature	56	-4.036***	0.339	55	-2.050***	0.339
Voc:Construction Engin.	57	-4.079***	0.259	58	-2.221***	0.259
Voc:Hotel Restaurant	58	-4.212***	0.242	56	-2.056***	0.242
Uni:Regional Science	59	-4.344***	0.330	59	-2.228***	0.330
Uni:History	60	-4.722***	0.307	61	-2.566***	0.307
Uni:Music	61	-5.139***	0.353	60	-2.411***	0.353
Uni:Social Work	62	-6.554***	0.374	62	-4.059***	0.374
Voc:Gardening	63	-6.781***	0.287	63	-4.323***	0.287
Total number of fields	63			63		

S.E. calculated using the delta method. Significance levels: * : 10% ** : 5% * : 1%

Source: Estimation based on German Micro Census, years 2005-2009
Notes: Excess returns and risk are calculated using a discount rate of $\gamma = 1.03$.

Table A2.13: Returns and standardized Returns: All fields, women

	Returns $E[\hat{R}_j] - \overline{\hat{R}}$			Standardized Returns Sj		
	Rank	Return	S.E.	Rank	Return	S.E.
Uni:Dentistry	1	4.994***	0.408	3	1.941***	0.408
AppSc:Management Science	2	4.800***	0.560	1	3.697***	0.560
Uni:Medicine	3	4.110***	0.413	2	2.059***	0.413
AppSc:Finance and Insurance	4	2.570***	0.548	4	1.819***	0.548
Uni:Teaching	5	2.401***	0.540	5	1.394**	0.540
AppSc:Business	6	2.076***	0.439	6	1.159**	0.439
Voc:Finance and Insurance	7	1.225*	0.551	7	0.807	0.551
AppSc:Computer Science	8	1.108**	0.387	9	0.576	0.387
Voc:Anglistic	9	1.081*	0.470	8	0.618	0.470
Voc:Marketing	10	0.689	0.466	10	0.397	0.466
Uni:Law	11	0.466	0.436	11	0.214	0.436
Uni:Business	12	0.405	0.402	12	0.207	0.402
Voc:Chemical Engin.	13	0.027	0.478	13	0.016	0.478
Uni:Computer Science	14	-0.028	0.404	14	-0.017	0.404
Uni:Psychology	15	-0.037	0.476	15	-0.021	0.476
AppSc:Social Work	16	-0.045	0.522	16	-0.031	0.522
Voc:Transport	17	-0.060	0.467	17	-0.039	0.467
Voc:Nursing	18	-0.148	0.519	19	-0.107	0.519
Voc:Management Science	19	-0.155	0.527	18	-0.101	0.527
Voc:Accounting	20	-0.304	0.516	20	-0.174	0.516
Uni:Chemistry	21	-0.680	0.437	21	-0.374	0.437
Voc:Business	22	-0.874	0.476	23	-0.526	0.476
Uni:Maths	23	-0.884*	0.415	22	-0.478	0.415
Uni:Political Science	24	-1.007*	0.397	24	-0.536	0.397
Voc:Manufacturing Engin.	25	-1.010*	0.451	25	-0.603	0.451
Voc:Social Work	26	-1.039	0.540	28	-0.720	0.540
AppSc:Educational Science	27	-1.115*	0.501	26	-0.686	0.501
Voc:Media	28	-1.357**	0.464	29	-0.735	0.464
Uni:Economics	29	-1.423***	0.423	27	-0.694	0.423
Voc:Educational Science	30	-1.532**	0.534	37	-1.114*	0.534
Uni:Biology	31	-1.656***	0.433	30	-0.935*	0.433
Uni:Educational Science	32	-1.688***	0.511	32	-0.990	0.511
Voc:Medical Services	33	-1.708**	0.541	35	-1.075*	0.541
Voc:Trade and Logistic	34	-1.711***	0.491	33	-1.022*	0.491
Voc:Tourism	35	-1.751***	0.485	36	-1.112*	0.485
Uni:German Literature	36	-1.828***	0.453	31	-0.981*	0.453
Uni:Anglistic	37	-2.035***	0.432	34	-1.037*	0.432
Uni:Chemical Engin.	38	-2.264***	0.428	39	-1.223**	0.428
Uni:Manufacturing Engin.	39	-2.407***	0.401	38	-1.123**	0.401
Uni:Geo Science	40	-2.409***	0.448	46	-1.508***	0.448
Voc:Office Assistant	41	-2.416***	0.498	45	-1.484**	0.498
AppSc:Architecture	42	-2.425***	0.449	43	-1.434**	0.449
AppSc:Maths	43	-2.526***	0.395	40	-1.320***	0.395
AppSc:Manufacturing Engin.	44	-2.567***	0.357	42	-1.415***	0.357
Uni:History	45	-2.619***	0.426	41	-1.371**	0.426
Voc:Hotel Restaurant	46	-2.778***	0.441	44	-1.454***	0.441
Voc:Personal Services	47	-3.012***	0.531	47	-1.614**	0.531
Uni:Regional Science	48	-3.089***	0.427	49	-1.869***	0.427
AppSc:Construction Engin.	49	-3.323***	0.382	51	-1.930***	0.382
Uni:Construction Engin.	50	-3.587***	0.411	52	-2.127***	0.411
Uni:Architecture	51	-3.609***	0.412	50	-1.882***	0.412
Uni:Music	52	-3.725***	0.477	48	-1.857***	0.477
Voc:Dentistry	53	-3.769***	0.499	53	-2.301***	0.499
Uni:Social Work	54	-4.038***	0.522	54	-2.868***	0.522
Voc:Textile	55	-5.087***	0.416	55	-2.892***	0.416
Voc:Beauty	56	-6.617***	0.459	56	-3.336***	0.459
Total number of fields	56			56		

S.E. calculated using the delta method. Significance levels: * : 10% ** : 5% * : 1%

Source: Estimation based on German Micro Census, years 2005-2009
Notes: Excess returns and risk are calculated using a discount rate of $\gamma = 1.03$.

Figure A2.4: Age-earnings profile: Men

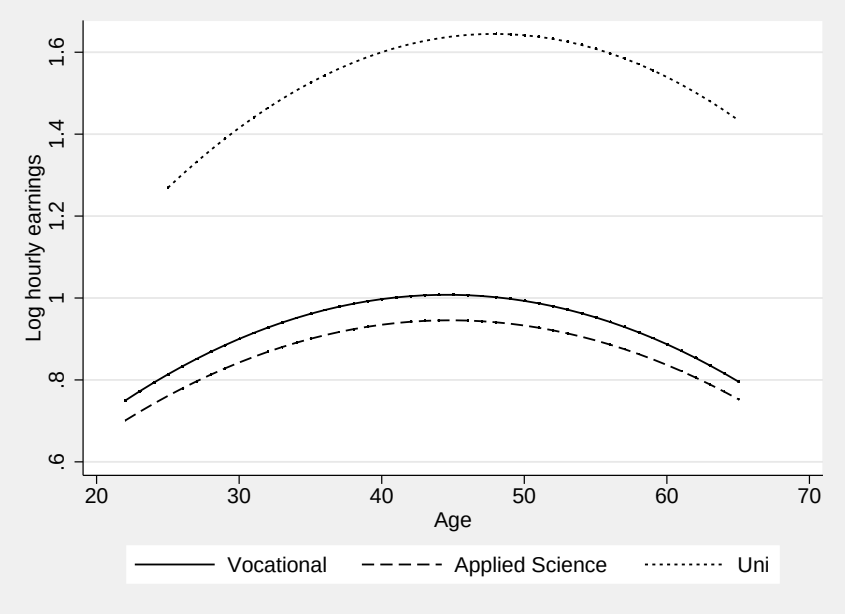
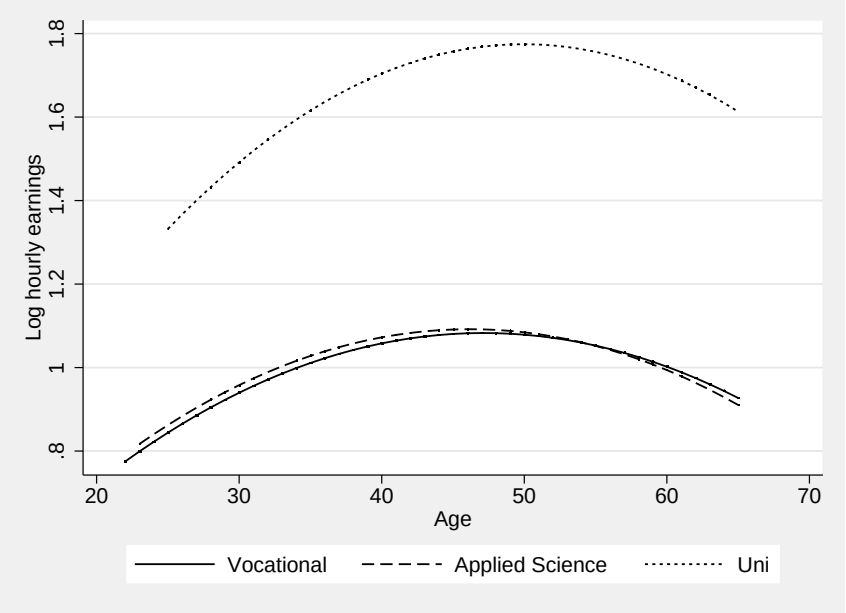


Figure A2.5: Age-earnings profile: Women



Chapter 3

Secondary school choice and labor market expectations

3.1 Introduction

Educational degrees strongly determine future income and labor market participation. There are substantial differences in earnings and unemployment risks between educational degrees, which points to the importance of early education decisions on labor market outcomes. In most countries a specific type of high school degree is required to seek higher education. Therefore, the secondary school degree is strongly correlated to later qualifications and labor market prospects. Given that the type of the secondary school degree is the basis for any further educational opportunities and career possibilities, paper aims to understand the determinants of the secondary school degree choice of 16 year old students.

Human capital theory assumes that expected monetary rewards drive the decision to invest in education (Becker, 1964). For the case of secondary education the investment decision does not only depend on the value of the years in secondary school, but on an additional value of having the opportunity for further education. Following Human Capital Theory, individuals invest in education as long as they expect the returns to education to be greater than the costs. The major part of costs comes in form of forgone earnings while continuing school. The monetary benefits from education are a higher earnings and lower unemployment probability in later work life. Hence, the wage structure and the unemployment rates resulting from different educational levels should, apart from the individuals motivation and ability, play a role in the individual's secondary school degree choice.

In Germany students choose between three different secondary school degrees. Depending on the secondary school degree, the students have different options for further education and, consequently, widely varying labor market outcomes and career opportunities. At the same time, the number of years necessary to obtain a degree vary by degree and hence the opportunity costs corresponding to the degrees differ. Only one of the three possible school degrees, the *Abitur* (upper secondary degree), gives a student the option to seek further education at the university level. The other degrees are the basis for non-academic vocational training. This variety of options will serve as the framework for the model.

To obtain a high level of education is not only beneficial for the individual, but also governments aim to increase the number of high educated citizens, with high educated being defined as having a university degree. One way to increase the number of students with a high-qualifying degree could be to decrease the years required to earn the *Abitur*, while keeping the skills taught constant. This will diminish opportunity costs and increase lifetime earnings as individuals enter the labor market earlier . International comparison shows that upper secondary school graduates eligible for higher education in Germany are comparatively older than their counterparts in comparable countries. In Germany students are, on average, 19, while in the Netherlands graduation age is 17-18, 18 years in the US and 17 years in Russia (OECD, 2005). The lengthy curriculum required to earn the university entrance certificate imply rather high opportunity costs in form of forgone earnings, which might deter young people, especially those from low income families, from continuing their education. As a results, almost all German federal states have implemented a school reform (G12 reform) designed to reduce the time spend in secondary school by eliminating the 13th year. Estimating the effect of this reform on the probability to earn the *Abitur* is another goal of this study.

To analyze the role of earnings expectations on the secondary school choice I estimate a model in two steps. First, I estimate future labor market earnings and unemployment probabilities for the young students under counterfactual school decisions. Second, the selection into the different degrees is modeled as a discrete choice problem. The choice depends on the expected earnings and unemployment probabilities of each degree and individual characteristics. The discrete choice problem is estimated with a conditional logit model, using data from the BIBB (Federal Institute for Vocational Education and Training) Transition Survey 2006 and the German Socio-Economic Panel (SOEP). The

model is then used to simulate the impact of changes in the educational system, in particular the reduction in years of schooling to earn the university entrance diploma.

The paper is organized as follows: The next section gives an overview of the literature and theoretical background. In section 3.3 I describe the school system and choices of school degrees in Germany. Section 3.4 describes the methodology. I present the datasets and descriptive statistics in section 3.5. In section 3.6 the results are discussed and section 3.7 concludes.

3.2 Literature and theory

The effect of expected earnings on educational decisions is analyzed in many studies. Predominant in this stream of literature are studies on the effect of anticipated future earnings on the decision to seek higher education (e.g. university). These studies suggest that expected earnings are important for the decision whether or not to attend college (for example, Willis and Rosen (1979), Kane (1994) or Wilson et al. (2005)). Other studies find that increasing risk, i.e. the variance in the payoff for education, reduces investments in education (for example, Carneiro et al. (2003), Hartog and Diaz-Serrano (2007) or Fossen and Glocker (2011)). Building on their studies on the entrance to post-secondary education, I analyze if, in addition to socio-economic influences, the expectations a student has about his future educational achievements and labor market outcomes play a role in the secondary school degree choice.

The impact of expected lifetime earnings on the choice of the secondary school track (academic or vocational) is analyzed by Lopez-Mayan (2010). She estimates a structural model in which she links the options available to Spanish students after compulsory schooling to their expected lifetime earnings. She finds that a change in annual earnings associated with a certain high school diploma may alter the qualifications of Spanish youth and significantly reduce drop out rates in post-secondary education. Dustmann (2004) analyzes the determinants of school track choice for Germany. He investigates the extent to which the choice of secondary school is related to parental characteristics and how future wages are affected by this early choice. He finds that differences in parental background translate, via their association with secondary track school choice, into sizeable wage differences.

One issue arising when testing the impact of earnings on schooling decision is that earnings are only observed after the schooling investment is complete.

(Buchinsky and Leslie, 2010, p.542,) state that *"even if the importance of expectations to individuals' educational choices has long been recognized, it is still a challenge to empiricists because expectations are obviously unobserved and because we can never be certain how individuals use the available information to assess the future"*. In the literature there are two approaches to deal with this challenge. The first approach is based on Willis and Rosen (1979). They assume that youths know their potential earnings profile and use it to predict their expected earnings. The second approach, suggested by Manski (1993), assumes that young people form their expectations about their potential earnings by observing the earnings realized by members of the preceding generations. In this paper I follow the approach of Manski (1993). I assume that the young students observe older individuals who are similar in their observable characteristics with the different secondary school degrees. Based on what they observe from the earnings of the older individuals they form their expectations about their future earnings under the counterfactual degree choices.

Another stream of literature aims to explain the social inequalities in educational attainment by socio-economic-status. Considering that large inequalities in educational attainment exist, it can be assumed that the sensitivity to earnings expectations in educational choices might be heterogenous for different groups. Both theoretical considerations and empirical evidence find large differences in educational achievements for students from different socio-economic backgrounds. For the case of the German educational system Becker and Hecken (2009) describe two specific reasons for the unequal attainment. Firstly, parents with poor educational backgrounds often choose a short and less ambitious education for their own children. Such early decisions discourage the children from earning a secondary degree that qualifies them for further education. Secondly, even after the completion of secondary schooling, Germany's dual system of vocational training offers an attractive alternative and diverts working-class children from entering university education. In the same respect, the vocational training system might divert students from earning the *Abitur* because the *Abitur* is not a requirement for vocational training.

Additionally, financial aspects might be more important in the degree decision for students from families with low socio-economic status than for students with high socio-economic status. In the vocational training system young people can get a professional education while working for a firm and earning an income. While the earnings of young people are rather low while in vocational training, the possibility to earn money might be an incentive to leave school, es-

pecially for young people with a low socio-economic background. At the same time, young people from a lower socio-economic background might evaluate the costs, in form of forgone earnings, of obtaining an *Abitur* to be higher than students with a high socio-economic background. Hence, for them an increase in expected earnings over the lifetime with a higher degree have to be rather high in order to change their educational choice.

Another reason for different magnitudes of expected monetary benefits effects from education on the secondary school choice is that for students whose parents have a general or intermediate degree, earning an intermediate degree is already a success, while children from families with a stronger educational background are expected to earn an *Abitur* (status maintenance hypothesis based on Boudon (1974)). As opposed to the hypothesis by Becker and Hecken (2009), this hypothesis points to a higher sensitivity to earnings of students from a low socio-economic background. Students from highly educated families might be less sensitive to changes in their earnings prospectives because they will follow the educational path of their parents regardless. Both considerations imply that expected earnings might impact students from a different socio-economic background with different magnitude. My estimation results show that for men the first hypothesis seems to be true (men from a low socio-economic background react less to changed earnings expectations than the whole sample), while for women the status maintenance hypothesis seems to hold. In any case, changes in the wage structure or policies changing the expectations of lifetime earning with different school degrees would then also change the socio-economic distribution among the share of students with different levels of secondary education.

3.3 Institutional background

3.3.1 The educational system

In Germany, after their primary education, children generally continue their education in one of three types of secondary schools. Secondary school curriculums vary in length, and result in a degree after 9, 10, 12 or 13 years. The type of secondary school that a student attends is decided by a combination of the teacher's recommendation, parent's will and/or grades depending, on the federal state. This decision is made, in most federal states, after four years of

primary education, at the age of 10.[40] The school requiring the least amount of additional time after primary education is the *Hauptschule* (General School). After five years at a *Hauptschule*, students earn a general degree. This type of degree provides the basis for vocational training in blue-collar professions. Attending a *Realschule* (Intermediate School) for a further 6 years leads to an intermediate school degree. The intermediate degree prepares for vocational training in blue- and white-collar professions. At a *Gymnasium* (Upper Secondary School), after an additional 8 years, students take an examination in order to earn an *Abitur*, the degree required for admission to a university.[41] In addition to the three aforementioned traditional paths, students can leave the *Gymnasium* after 12 years with an entrance certificate for a university of applied science (technical upper secondary degree). A technical degree can also be obtained at *Fachoberschule*(Technical Upper Secondary School) or a *Berufsfachschule* (Non-academic Upper Secondary School) depending on the federal state.[42]

The type of school that a student attends after elementary school has a strong impact on the degree choice. Nevertheless, the initial secondary school that a student attends is not necessarily the final secondary school, as students do have the ability to switch tracks and, thus, the secondary school degree that they earn. Conditional on grades, students can transfer from one school type to another in order to achieve a different degree. For example, a student at an intermediate school can transfer to a technical school or upper school at the beginning of a new school year, as long as their grades are good enough. At the same time, students at an upper secondary school can leave the school after 6 additional years with an intermediate degree, or after 8 additional years with a technical degree. In addition, students can upgrade their degree by enrolling at another school type after earning their first degree. For example, students with an intermediate degree can continue schooling at a technical upper secondary school or a non-academic high school in order to earn the technical upper

[40]In Berlin, Brandenburg, and Mecklenburg-Western Pomerania, this decision is made after 6 years of primary education, at the age of 12. From 1981 through 2004 Lower Saxonyalso delayed tracking until after grade 6.

[41]Beginning in 2007 federal states reduced the total time required to earn the *Abitur* from 13 to 12 years, or 9 to 8 additional years beyond primary education. By 2016 all German federal states will have implemented this reform.

[42]Note that about 10 percent of students attend a school type outside the three-track system. In additional to the three main tracks, most states offer comprehensive schools. At this type of school students with different achievement level learn together for a longer period. The various forms of schooling are all organized under the same roof and all types of secondary school degrees can be obtained.

degree. Hence, while parents and teachers determine the type of secondary school a student attends after primary school, this decision can be revisited by the student at an later age.[43]

3.3.2 The G12 reform

In Germany the responsibility for school policy is at the state level and the educational system varies from state to state. In 2007 most federal states decided to reduce the number of years needed to earn an *Abitur* by one year. This reform has been enacted in all but one (Rhineland-Palatinate) federal states. Because of state sovereignty, the time of introduction and the implementation procedure varies between states. The first federal state to have students exit school with an upper degree after 12 years was Saxony-Anhaltin 2007. Mecklenburg-Western Pomeraniafollowed in 2008. The implementation across all of Germany will be completed by 2016.[44] The main argument for reducing the number of school years required to earn the *Abitur* is the high age of graduating students. The academic requirements for the degree remained unchanged. Extra hours during the 9th and 10th grade, along with minor changes to the curriculum, make up for the loss of one year. Hypothetical calculations on the increase in lifetime earnings through the reduction of school years will be made in section 3.6.3. It will be analyzed if the new policy encourages more students, especially from low socio-economic backgrounds, to earn an *Abitur*.

3.4 Estimation strategy

To estimate the effect of lifetime earnings on the secondary school choice, I proceed in two steps. At first the expected lifetime earnings for each student under counterfactual degree choices are calculated. Second, the values for the expected earnings are used to estimate the sensitivity of educational choices to changes in the earnings prospectives.

[43]Dustmann et al. (2012) show that the type of secondary school attended after elementary school has little impact on the type of secondary school degree received. An explanation for this is that there is a substantial up- and downgrading between school types at the age of 15/16. Further educational choices are made at the end of secondary schooling, at age of 18/19.

[44]in the former GDR secondary school lasted for 8 years. Two of the six federal states (Saxonyand Thuringia) retained their 8 year curriculum system after 1989.

3.4.1 Expected lifetime earnings

In the first step of the analysis the expected individual wage profiles and the unemployment probability for the young students over their life is predicted. The wage profiles and the unemployment probabilities are predicted for each person under the four counterfactual alternative states (s_j). That means under the counterfactual condition that a person obtained a general degree and a professional degree in vocational training, an intermediate degree and a professional degree in vocational training, an *Abitur* followed by vocational training or an *Abitur* and a university degree. Following Manski (1993), I assume that young people form their expectations about future earnings and unemployment risk by looking at people from older cohorts with similar characteristics.

When using this method there might be a problem of cohort effects, meaning that the returns to education change over time and that young students can not be sure they will have the same benefits from a degree as older cohorts. To keep the problem of cohort effects as small as possible I assume that the young students observe older people born 2 to 25 years before them, up to the age of 45.[45] Additionally, I exclude students living in the eastern states of Germany because of severe changes in the labor market. Because of the age restriction to reduce cohort effects lifetime earnings are approximated with the expected earnings from the time of entering the labor market through the age of 45.

The information from older, working, individuals in the SOEP are used to forecast the expected earnings of the young people. I estimate the following standard Mincer wage equation (Mincer, 1974) to predict the earnings:

$$Log(W_i j) = \alpha_{0j} + \alpha_{1j} * age_{ij} + \alpha_{2j} * age_{ij}^2 + Region_{ij} * \alpha'_{3j} + \epsilon_{ij} \quad \text{with j=1...4} \tag{3.1}$$

The earnings depend on age and the region a student lives in. The wage equation only contains variables that are known by the students when they revisit their secondary school choice at the age of about 16. Hence, I can not include variables, as for example, the grades from their school transcripts as possible determinants of wages, as this is only known by the student after the choice is made. The coefficients from eq. 3.1 are then used to calculate

[45] The graduates from the different school tracks enter the labor market at different ages due to the varying length of time to graduation. Individuals with an intermediate degree and vocational education are expected to start working at age 20. For individuals with an upper (technical) degree and vocational training, working age starts at age 22 (21). Individuals who attended university are assumed to start working at 23 (technical degree + technical college), 24 (upper degree + technical college), or 25 (upper secondary degree and university).

four counterfactual net present values of expected lifetime earnings for each young person.[46] The average yearly gross income from labor for each age are determined and added up from the start of a young person into the labor market through the age of 45. The earnings in each period are discounted with a discount rate of $\gamma = 1.03$. The discounted value of the lifetime earnings is denoted as net present value of earnings (npv) and calculated as follows:

$$\begin{aligned} \hat{NPV}_{ij} &= \sum_{t_w}^{45} \frac{1}{\gamma^{exper}} \left(\sum_{j=1}^{J} \hat{\alpha}_{1j} * age_{ij} + \hat{\alpha}_{2j} * age_{ij}^2 + Region_{ij} * \alpha'_{3j} \right) \qquad (3.2) \\ \text{with} & \\ t_w &= \text{Age of entrance into the labor market} \\ \text{exper} &= \text{Age - } t_w \end{aligned}$$

The lifetime earnings vary by secondary school degree and the post-secondary educational choice. I assume that the students have not yet made their decision about the higher education track when they decide about the secondary school degree. As mentioned before, a general degree and an intermediate degree can only be followed with vocational training. A secondary degree, thus, can be upgraded by either vocational training or an academic education. Hence, for the choice of the general or intermediate degree only one value for the expected earnings has to be estimated. For the higher degrees two values have to be determined because of the different options for post-secondary education. For these degrees I will weight the two net present values with the entrance probability (p_{ik}) of a student into the further paths k ($k = 1, 2$). The entrance probability for the further educational paths are based on the grade in the last transcript, when the student is 17 years old. Table A3.1 presents the distribution into the further educational paths conditional on the grade in the last transcript. The lifetime returns for individual i with degree j can than be written as:

$$\hat{R}_{ijk} = p_{ik} * NPV_{ij} \qquad (3.3)$$

It is well-known that education is closely related to the occurrence of unemployment. Beyond earnings expectations, I assume that the young students

[46] Due to the loglinear functional form of the wage equation and assuming that the residuals are normally distributed, the prediction is given by $exp(\hat{\beta}X + 0.5\sigma^2)$, where $\hat{\beta}$ is the vector of estimated coefficients, X the vector of explanatory variables and σ the standard error of the prediction (cf. Greene (2008)).

also form expectations about their chance of being unemployed depending on the chosen school degree. Unemployment risk varies by degree choice. To include the unemployment risk in my estimation I follow Fossen and Glocker (2011). When unemployed, a person receives benefits at the unemployment benefit rate (UBR) set at 63 percent of the net wage the person would otherwise receive. This value represents a simplified model of the German legislation for temporary unemployment.[47] The assumption is that agents expect potential unemployment to last no longer than the period during which the unemployment benefit can be received, usually one year. Since, official data on unemployment usual does not distinguish between the secondary school degrees but only the professional degrees, I estimate the unemployment rates for the young individuals based on what I observe from the older cohort. Lifetime earnings adjusted for the risk of unemployment are:

$$\hat{R}^{ue}_{ijk} = ((1 - risk^{ue}_{j}) + risk^{ue}_{j} UBR)\hat{R}_{ijk} \tag{3.4}$$

$$\tag{3.5}$$

3.4.2 Conditional logit model

The effect of the expected lifetime earnings on the decision about the secondary school degree is estimated with a conditional logit model (Greene (2008)). It can be assumed that the students choose the secondary school degree that maximize their utility. Suppose each student selects his secondary school degree from D mutually exclusive alternatives in a manner that yields the greatest utility. In that case, the utility of student i with a degree d, where $d = 1, ..., 3$ can be written as

$$U_{id} = V(Y_d, X_i) + \xi_{id}. \tag{3.6}$$

Where the chosen degree can be a general degree, an intermediate degree or an *Abitur*. Y_d measures the attributes of the chosen degree d that influence the financial attractiveness of a degree to the student. X_i is a vector of observed student characteristics that influence the students choice. These include parental background variables, former school choices and attitudes toward school. The probability that student i chooses degree d is:

[47] Unemployment benefits in Germany (Arbeitslosengeld I) depend on the last net wage of an unemployed person. The rate is 60 percent of net earnings for individuals without children and 67 percent for children. I use the mean value of the two rates.

$$p_{id} = Pr(U_{id} \geq U_{il}),\ \text{l=1,..., D.} \tag{3.7}$$

The error term ξ_{id} is assumed to be independent across degrees for each individual, that is, the likelihood that a particular degree is chosen over another is independent of other alternatives. If these error terms follow a standard Type 1 extreme value distribution, the probability that individual i chooses degree d can be derived to be:[48]

$$p_{dil} = \frac{exp(y'_{idk}\beta + x'_i\gamma_i)}{\sum_{l=1}^{J} exp(y'_{ild}\beta + x'_i\gamma_i))}. \tag{3.8}$$

In a conditional logit model, individual characteristics that do not vary across degrees would be dropped in the regression if included directly. However, their effects can be controlled for by interacting these variables with a set of degree dummies. These factors are assumed to affect the degree choice through their influence on the valuation of the degree specific attributes.

3.5 Data and sample description

3.5.1 Data

The analysis is based on the BIBB Transition Survey 2006 conducted by the Bundesinstitut für Berufsbildung (BIBB), the Federal Institute for Vocational Education and Training, along with German Socio-Economic Panel (SOEP) waves from 1991 through 2009. The BIBB Transition Survey is a survey in which 7,230 young people born between 1982 to 1988 are asked retrospective questions about their educational and occupational attainment process after primary education. The survey contains detailed information on all schooling and occupational decisions of the participants through 2006. The advantage of the data is that it contains detailed information about the single steps a young person took in the educational system. Not only is the highest degree earned reported, but all degrees earned, the types of school, grades on their transcript, as well as their attitude toward school. Further, the data set contains information about parental education, occupational status and nationality. A drawback of the data is that the young people are only observed through the age of 21 to 24; but not later. For this reason, I cannot observe wages from

[48]The density function of the error term is $f(e) = exp[-e^{-exp(-e)}]$.

this survey.

To predicted future earnings for the young people under counterfactual educational choices, I use information from the SOEP. The SOEP is a representative yearly panel survey that collects detailed information about the socio-economic situation of (currently) more than 21,000 people, living in approximately 12,000 households across Germany.

I assume that the young students observe the earnings of older individuals in order to infer what they might earn in their later working life conditional the secondary education chosen. I assume that young people observe older people who are at least two years older and are already working (reference group). In my specification young people only form expectations about their future earnings from the year they start working through the age of 45.

I do not consider a longer horizon in order to avoid severe problems with cohort bias. In my chosen specification the young people observe older working people who are at most 25 years older than they are. If I considered a longer horizon, I would have to assume that wages and job opportunities remaind fairly stable across the young cohort and cohorts born more than a generation before them. Because of technological change and the educational expansion in the 1970's, labor market opportunities and wages have changed significant over time. For that reason, it seems implausible that young people will use older cohorts as a reference group. The chosen reference group was born at the earliest in 1957 and profited from the educational expansion. For the same reason, I do not estimate the model for people living in the former East Germany. In my specification, young people living in the eastern states of Germany would form their expectations about their future earnings based on the earnings of older people in the same cohort. Since, the older cohort obtained their education and spent most of their working life in the GDR, the comparison would not be valid. All monetary variables, and therefore all monetary results, are deflated by the Consumer Price Index (2005=100).

3.5.2 Sample description

The data allows me to identify the highest degree that a student earned in the secondary school system as well as any other degrees and the initial school that the student attended after primary education. In general students can leave school with a general degree, an intermediate degree, a technical degree, or an *Abitur*. Students can also leave school without any degree. About 7 percent

of students leave school without a degree. In my study these students are excluded from the sample. As mentioned before, I also exclude students living in former East German states. My final working sample contains 1,203 women and 1,212 men from the BIBB survey. Table A3.2 describes the variables used in the analysis and reports sample means for the sample of students in the BIBB-dataset. The first rows of the table show the distribution of men and women across the three types of school. The smallest share of students attends a general school after primary education: 22 percent of women and 28 percent of men. Intermediate schools are attended by 30 percent of both men and women. The largest share of students attend a *Gymnasium*. 49 percent of all female students and 43 percent of male students attend a Gymnasium.

The outcome variable of my estimation is the final secondary school degree earned. As already shown here, the type of school that a student attends immediately after primary education does not fully predict the final secondary education degree earned. The share of students who leave school with a general degree as their final degree, for example, is much smaller than the share of students who started at a general school. On average, 13 percent of women and 22 percent of men leave school with a general degree. The intermediate degree is obtained by 34 percent of female and male students. The *Abitur* is earned by 47 percent of women, but only 37 percent of men. Of all students with an *Abitur*, 6 percent of women and 7 percent of men also obtained the technical degree. Since the number of students who leave school with a technical degree is rather low and both degrees are followed by the option to seek higher education I will not distinguish between a technical and an *Abitur* in the analysis.

To control for parental background, I use information on parents' education and parents' country of birth and if parents were separated when the child was 15 years old as control variables. The numbers reveal that, on average, the educational attainments of both mother and father are lower than that of their offspring. In particular, the number of individuals with an *Abitur* is a lot smaller for the parental generation. Also, the differences between the educational level of men and women changed. While in the young sample females are a lot more likely to receive an *Abitur*, the opposite is true for the parental generation. Some 17 percent of fathers and 15 percent of mothers were not born in Germany, while 11 percent of parents separated before the child was 15. To control for the young person's attitude toward school, I include a variable asking how much the student liked elementary school. The variable is equal to one if the individual liked elementary school "very much" or "much",

with 79 percent of women and 64 percent of men reporting that they liked elementary school much or very much.

Table 3.1 shows the percentage of male students who finished their secondary education with a different degree than the degree expected from their initial school choice. Table 3.2 shows the same number for female students. The majority of students continues at their initial school track to earn their degree. However, students can transfer between schools. On average, women are more likely to transfer to a school in order to receive a higher degree than men. Students who are tracked into a general school are the most likely to upgrade their degree. Only 49 percent of the women who originally chose to earn a general degree leave the school system with this degree. Men, who started at a general school, on the other hand, are less likely to upgrade from a general degree with 67 percent earning a general degree. Most students who upgrade from a general school upgrade to an intermediate degree. However almost 5 percent of women (3 percent of men) earn a technical degree while 3 percent (3 percent of men) earn an *Abitur*. Approximately 66 percent of women and 64 percent of men starting at an intermediate school earn an intermediate degree . Of those starting intermediate school, 30 percent of women and 26 percent of men upgrade to an *Abitur*. Students at a Gymnasium are the least likely to transfer schools because there is no way to upgrade from an *Abitur*. Still, 18 percent of women leave Gymnasium before graduation and obtain either a technical degree (5 percent) or an intermediate degree (12 percent). For men this number is even higher: 24 percent do not complete Gymnasium, with 6 percent earning a technical degree and 18 percent an intermediate degree.[49] This show that students can revise their initial school track choice and a significant share of students takes the chance to upgrade their secondary school degree.

3.6 Results

3.6.1 Variation of lifetime earnings

The mean values of the expected lifetime earnings adjusted for the unemployment probability are given in Table 3.3. The last two rows in Table 3.3 show the expected average earnings of individuals with an *Abitur* or technical degree after weighing the expected earnings with the entrance probability into

[49] About the same rates of school transfers are found when checking SOEP data. Results are available upon request.

Table 3.1: School transition: Secondary school degree by first secondary school attended, men (%)

	Highest school degree received			
Initial secondary school choice	General degree	Intermediate degree	Technical degree	Upper secondary degree
General school	66.56	27.48	2.98	2.98
Intermediate school	9.35	64.80	10.59	15.26
Upper secondary school	1.08	17.28	5.83	75.81
N	236	371	70	409

Source: BIBB Transition Survey 2006.

Table 3.2: School transition: Secondary school degree by first secondary school attended, women (%)

	Highest school degree received			
Initial secondary school choice	General degree	Intermediate degree	Technical degree	Upper secondary degree
General school	49.36	42.98	4.68	2.98
Intermediate school	4.06	66.25	8.44	21.25
Upper secondary school	0.75	11.94	5.04	82.28
N	133	377	65	516

Source: BIBB Transition Survey 2006.

the post-secondary educational track. Table 3.3 shows the estimates for the unemployment probabilities for men and women in columns 1 and 4. Taking unemployment risk into account reduces expected earnings in all alternatives, but most for the general degree path.

For all students with vocational training, earnings vary with respect to the secondary degree. Especially for women obtaining an intermediate degree, it makes a large difference in later labor market earnings compared to the general degree. Females with an intermediate degree earn, on average, 20 percent more than females with a general degree. For men the returns to an intermediate degree are, at 11 percent, smaller than for women. The difference might be driven by the fact that young men with a general degree are more likely to get trained in crafts with fairly good job prospectives while jobs for women with a general degree are concentrated in low paid jobs like retail sales. The returns to the upper secondary degree are also higher for women than for men. For men with a vocational education it makes almost no difference if they obtained an intermediate degree or an *Abitur*. For men, earnings are only 2 percent higher with an *Abitur*. Women, on the opposite, benefit from the university entrance certificate even if they do not take up the option to attain an

Table 3.3: Expected lifetime earnings and unemployment probability (UE): By educational choices and sex

	Men			Women		
Educational Choice	UE (%)	Mean	S.E.	UE (%)	Mean	S.E.
	1	2	3	4	5	6
General degree + Vocational training	5.9 %	488,086	15,866	6.14 %	342,809	11,212
Intermediate degree + Vocational training	3.4 %	539,678	20,370	6 %	412,244	13,887
Upper secondary + Vocational training	3.2 %	552,469	15,397	2.9 %	454,710	15,991
Upper secondary + University	1.3 %	677,253	44,743	3 %	533,987	35,091
Weighted						
Upper secondary degree		621,774	32,908		504,733	28,514

Source: BIBB Transition Study 2006 and SOEP, waves 1991-2009.
Notes: To calculate the lifetime earnings I used annual earnings from labor of people observed working who are younger than 46 years.

academic education. The earnings of women who obtained the upper degree before entering vocational training are 10 percent higher than the earnings of women with an intermediate degree and vocational training. Women who do take up their option to go university have earnings that are 17 percent higher than earnings of women with vocational training. For men the lifetime earnings after graduating from university education are 23 percent higher than for vocational education with *Abitur*.

3.6.2 Estimation results

Table A3.3 for men and Table A3.4 for women give the coefficients of the conditional logit estimation. I estimate the model for three different sample specifications. The first column shows the coefficients for the whole sample of men and women, respectively. In addition to the estimates for the whole sample, column 2 provides the estimates for a group of students who initially attended an intermediate school. The third column shows the estimation results for students whose parents both do not have an *Abitur*. The positive signs of the coefficients on the net present value of earnings (npv) indicate that an increase in the expected lifetime earnings with one degree attracts people to graduate with that degree.

In order to be able to interpret the magnitude of the effect of lifetime earnings on the secondary degree choice, I calculate the marginal effects from the estimated coefficients. The most interesting effect is probably the effect of a change of earnings with an *Abitur* on the probability of choosing that degree. In the political discussion it is most relevant to increase the share of students

leaving school with an *Abitur* since these students are eligible to seek university education. For this reason I concentrate on the results for the *Abitur* in the remainder of the discussion. At first I will discuss the effects of a 10,000 Euro change in earnings on the share of students with a certain degree. Secondly, I will discuss how a reduction in school years required to earn an *Abitur* will increase the share of graduates earning an *Abitur*.

In the Table A3.5 and A3.6, I present the marginal effect of a change in the expected earnings on the degree choice for the three samples of women and men, respectively. The marginal effects are reported for a 10,000 Euro change in lifetime earnings. Panel A of the tables display the results for the full sample. As shown in other studies, men are more sensitive to changes in lifetime earnings than women. A 10,000 Euro increase in earnings with a general degree leads to an increase of male school leavers with a general degree of 1.8 %-points. The same increase for women leads to an increased share of women with a general degree of 0.7 %-points. The effect of an increase in lifetime earnings on the decision to obtain an intermediate degree are about the same as for the upper degree. As for the general degree, men are more sensitive to the increase than women. The probability to choose the upper degree would increase by 2.8 %-points for men and 1,7%-points for women, if the earnings prospectives were raised by 10,000 Euro (2.6 %-points and 1.5 %-points for the intermediate degree).

Theoretical considerations suggest that students who initially did not attend a Gymnasium need a greater financial incentive to continue to pursue the *Abitur* than students who already attend a Gymnasium. Students attending a *Gymnasium* can continue schooling at the school type they already attend, students in another type of school have to change school and, hence, have a higher cost of continuing school. The estimation results, though, show a different pattern. Panel B shows the sensitivity of a student who initially attended an intermediate school to an increase in earnings with an *Abitur*. Other than expected the sensitivity of men and women who initially attended an intermediate school is stronger than the sensitivity estimated for the full sample. The probability for male students who initially attended an intermediate school to switch to the *Gymnasium* increase by 4.5 %-points from 15 percent to 20 percent (see Table 3.1 for the baseline probability). The probability for female students to obtain the *Abitur*, despite the necessary transfer of schools, increases 3 %-points from 21 percent to 24 percent (see Table 3.2 for the baseline probability). Since the baseline probability of a "school upgrade" is higher for

women, the larger increase for men leads to a slight convergence of men and women who change school in order to receive an *Abitur*.

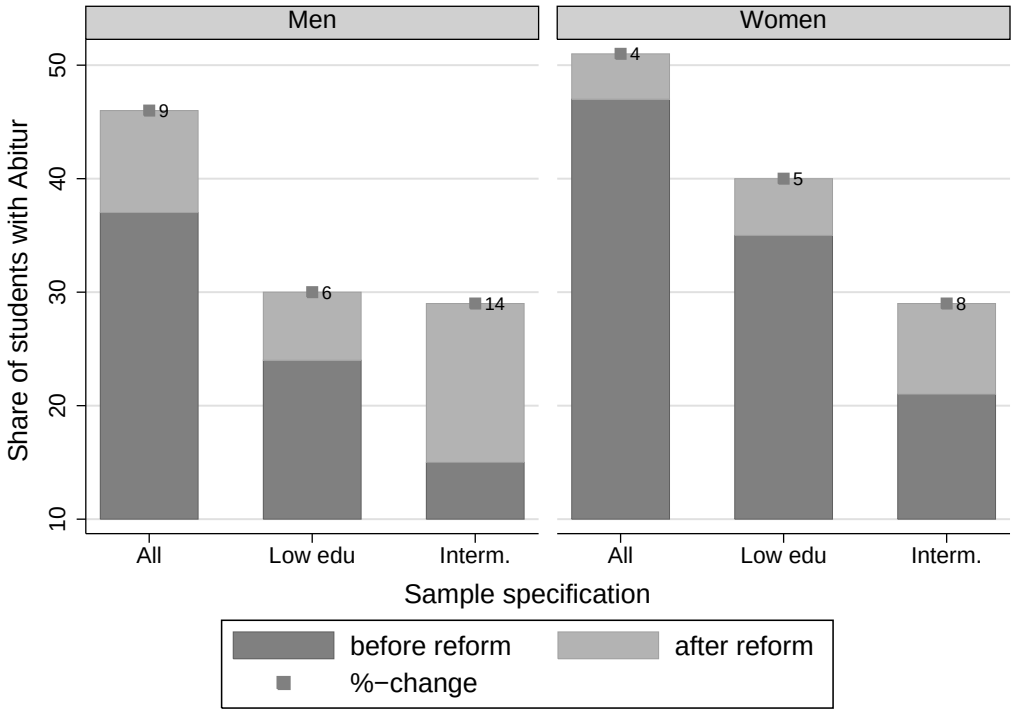
For a third specification, I calculate the marginal effect for students coming from a family where the parents do not have an *Abitur*. The results are given in Panel C. It emerges that male students who come from a family where none of the parents has an *Abitur* are less sensitive to changes in earnings with an *Abitur* than the full sample of men. This indicates that male students who come from an educational weaker background need stronger financial incentives to continue schooling than students whose parents took the same educational path. At the same time, the effect of lifetime earnings are not significantly different for the two groups of female students (2.0 %-points vs. 1.9 %-points).

3.6.3 School reform

As shown before, expectations about future earnings influence the degree decision. Therefore the estimates can be applied to simulate the effects of the shortening of the school duration. I calculate the additional earnings students can expect if they enter the labor market one year earlier than in the former system of 13 total years to earn an *Abitur*. The results are shown in Table A3.7 and A3.8. For men the additional earnings are 30,422 Euro (around 5 percent of lifetime earnings). For women the one year additional earnings lead to an increase of lifetime earnings of 26,195 Euro (around 5 percent of the full lifetime earnings). According to my estimations, this addition to lifetime earnings leads to a 8.5 %-points (baseline: 37 %-points) increase of men with a university entrance certificate and increases the share of women with a university entrance certificate by 4.2 %-points (baseline: 47 %-points). For students who come from an intermediate school the effect of the reform is even stronger. The estimates, depicted in Figure 3.1, indicate that the share of men who decide to switch to Gymnasium will increase by 13.6 %-points (baseline: 15 percent) and for women by 8 %-points (baseline: 21 percent). This means that the reform could actually attract more students to the upper secondary level and mitigate the gap between men and women with an *Abitur*.

In this exercise, I neglect that the price (e.g. wages) for students with an *Abitur* might decrease in the longrun if more students obtain the highest degree. Further, even if universities aim to provide enough places for additional students, restricted university entrance because more students are eligible for university could decrease earnings perspectives. In these cases the effect of

Figure 3.1: Simulated effect of the G12-reform on the share of students with *Abitur*



expected earnings on the degree choice would be overestimated.

3.7 Conclusion

In this study I analyze the determinants of secondary school choice as made by young students. More specifically, I seek to measure the impact of prospects on the labor market, represented by expected lifetime earnings adjusted for the unemployment probability. The model takes into account that students with different degrees have different options for further education after graduating from secondary school. The different options of further education conditional on the secondary school degree account for a large part of differences in earnings but earnings also differ widely among graduates from vocational training, but with different school degrees.

My estimates demonstrate that expected lifetime earnings have a smaller influence on secondary school choices for students whose parents do not have an *Abitur* compared to students with at least one parents who has an *Abitur*. Furthermore, I observe an impact of expected lifetime earnings that is differentiated by sex. Men are more sensitive to an increase in earnings than women. I also conclude that only a rather small increase in lifetime earnings are nec-

essary to attract students to continue school and earn the *Abitur*. Because of the greater sensitivity of men to expected earnings, an increase in expected earnings with an *Abitur* could lead to a convergence of men and women who leave school with this type of degree.

An important fact that emerges from my results is that students who initially chose an intermediate school are attracted to earn the *Abitur* because of the potentially greater earnings. Students who initially attended an intermediate school react stronger to an increase in expected earnings than the full sample of students. An increase in expected earnings through, for example, the reduction of the number of school years to earn an Abitur could increase the number of students who decide to "upgrade" their degree.

Although expected earnings play a role in the students' choice, other factors, which cannot be modeled here, might influence their decision. For one thing, I could not control for students' ability to continue schooling due to their grades or the possibility to transfer to a higher level school. Another issue arises when assuming that the price for a skill level decreases if more students attain this level. If the reduced years to the *Abitur* induce more students to follow that path, wages with earned with an *Abitur* might decrease. At the same time the probability to enter university might decrease since places at university might become scarce. Hence, the effect of expected earnings on the degree choice might be overestimated.

An ex-post evaluation of the actual shortening of the duration of secondary school could shed more light on the magnitude of overestimation. The first federal state to implement the reform, Saxony-Anhalt, graduated its first cohort of students with *Abitur* after 12 total years in 2007, the second state, Mecklenburg-Western Pomerania, followed in 2008. The time horizon is not long enough yet to profoundly investigate the magnitude of the effect of the reform on the share of upper secondary school graduates.

3.8 Appendix

3.8.A Tables and figures

Table A3.1: Post-secondary educational choice by grade, students with an upper secondary degree (%)

Grade	Vocational Training	Technical University	University
very good	18.03	12.02	69.95
good	33.74	15.85	50.41
satisfactory/fair	45.73	11.89	42.38

Source: SOEP, waves 1991-2009. Individuals born after 1974 and older than 21 years.
Notes: Mean of the grade in Math and German Language in the last transcript when the student was 17 years old.

Table A3.2: Sample distribution by sex (%)

	Women	Men
Sex	48.78	51.22
Initial secondary school attended		
General school	21.54	27.81
Intermediate school	29.33	29.56
Upper secondary school	49.13	42.63
Final secondary school degree		
General degree	12.55	22.28
Intermediate degree	34.00	33.75
Technical secondary degree	6.40	6.85
Upper secondary degree	47.05	37.13
Parents' education		
Father has an upper sec. degree	27.18	28.22
Mother has an upper sec. degree	21.20	21.37
Parents' nationality		
Father foreign	17.29	16.75
Mother foreign	15.96	15.02
Liked elementary school		
(Very) much	78.72	64.27
Parents separated		
Yes, before age 15	10.89	11.39
Grade in last report card		
(Very) good	74.31	71.37
N	1,203	1,212

Source: BIBB Transition Study 2006.
Notes: Grade 1 or 2 in the better subject(out of math and language) in last report card. Grades are declining from 1 to 4.

Table A3.3: Conditional logit estimates: Men

	Full sample		Intermediate School		Low educational background	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
	(1)		(2)		(3)	
$\hat{R}^{ue}_{ijk}$	0.00001	0.0000***	0.00002	0.0000***	0.00001	0.0000**
	Panel A: Intermediate degree					
Mother						
Has an upper sec. degree	0.499	0.284	-0.268	0.545	–	–
Is foreign	0.205	0.340	-0.004	0.944	0.085	0.423
Father						
Has an upper sec. degree	0.614	0.261*	-0.227	0.511	–	–
Is foreign	0.373	0.331	-0.336	0.940	0.554	0.407
Student						
Liked elementary very much	0.419	0.161**	-0.185	0.413	0.510	0.178**
Parents separated before age 15	0.010	0.231	-0.150	0.535	-0.1693	0.259
	Panel B: Upper secondary degree					
Mother						
Has an upper sec. degree	1.072	0.269***	-0.274	0.592	–	–
Is foreign	0.717	0.351*	0.210	1.039	0.711	0.448
Father						
Has an upper sec. degree	1.667	0.244***	0.642	0.542	–	–
Is foreign	-0.016	0.337	-0.443	1.020	-0.075	0.418
Student						
Liked elementary very much	0.927	0.168***	-0.002	0.458	1.027	0.197***
Parents separated before age 15	-0.646	0.262*	-0.402	0.620	-0.418	0.292
N	3636		966		2376	

Source: Own calculations based on SOEP waves 1991-2009 and BIBB Transistion Survey 2006.
Notes: Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A3.4: Conditional logit estimates: Women

	Full sample		Intermediate school		Low educational background	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
	(1)		(2)		(3)	
$\hat{R}^{ue}_{ijk}$	0.00001	0.0000*	0.00001	0.0000*	0.00001	0.0000*
	Panel A: Intermediate degree					
Mother						
Has an upper sec. degree	1.072	0.269***	-0.274	0.592	–	–
Is foreign	0.717	0.351*	0.210	1.040	0.711	0.448
Father						
Has an *Abitur*	1.662	0.244***	0.642	0.542	–	–
Is foreign	-0.016	0.337	-0.443	1.020	-0.075	0.418
Student						
Liked elementary very much	0.927	0.168***	-0.002	0.458	1.027	0.197***
Parents separated before age 15	-0.646	0.262*	-0.402	0.620	-0.418	0.292
	Panel B: Upper secondary degree					
Mother						
Has an upper sec. degree	1.072	0.269***	-0.274	0.592	–	–
Is foreign	0.717	0.351*	0.2108	1.040	0.711	0.448
Father						
Has an upper sec. degree	1.667	0.244***	0.642	0.542	–	–
Is foreign	-0.016	0.337	-0.443	1.020	-0.075	0.418
Student						
Liked elementary very much	0.927	0.168***	-0.002	0.458	1.027	0.197***
Parents separated before age 15	-0.646	0.262*	-0.402	0.620	-0.418	0.292
N	3609		960		2388	

Source: Own calculations based on SOEP waves 1991-2009 and BIBB Transistion Survey 2006.
Notes: Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A3.5: Marginal Effects of an 10,000 Euro change in lifetime earnings: Men

	General degree		Intermediate degree		Upper sec. degree	
Degree	Marg. Eff.	Std. Err.	Marg. Eff.	Std. Err.	Marg. Eff.	Std. Err.
	(1)		(2)		(3)	
			Panel A: All			
General	**0.018*****	0.005	-0.008***	0.002	-0.010***	0.003
Intermediate	-0.008***	0.002	**0.026*****	0.007	-0.018***	0.005
Upper secondary	-0.010***	0.003	-0.018***	0.005	**0.028*****	0.007
			Panel B: Coming from an intermediate school			
General	**0.022*****	0.007	-0.016***	0.005	-0.006***	0.002
Intermediate	-0.016***	0.005	**0.055*****	0.014	-0.039***	0.010
Upper secondary	-0.006***	0.002	-0.039***	0.010	**0.045*****	0.012
			Panel C: Low educational background			
General	**0.020*****	0.008	-0.011***	0.004	-0.009***	0.003
Intermediate	-0.011***	0.004	**0.023*****	0.009	-0.012***	0.005
Upper secondary	-0.009***	0.003	-0.012***	0.005	**0.020*****	0.008

Source: Own calculations based on SOEP waves 1991-2009 and BIBB Transistion Survey 2006.
Notes: Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A3.6: Marginal Effects of an 10,000 Euro change in lifetime earnings: Women

	General degree		Intermediate degree		Upper sec. degree	
Degree	Marg. Eff.	Std. Err.	Marg. Eff.	Std. Err.	Marg. Eff.	Std. Err.
	(1)		(2)		(3)	
			Panel A: All			
General	**0.007****	0.003	-0.003**	0.001	-0.004**	0.002
Intermediate	-0.003**	0.001	**0.015****	0.008	-0.013**	0.006
Upper secondary	-0.004**	0.002	-0.013**	0.006	**0.017****	0.008
			Panel B: Coming from an intermediate school			
General	**0.005***	0.003	-0.004*	0.002	-0.002*	0.001
Intermediate	-0.004*	0.002	**0.035****	0.015	-0.031**	0.014
Upper secondary	-0.002*	0.001	-0.031**	0.014	**0.033****	0.014
			Panel C: Low educational background			
General	**0.011****	0.005	-0.005**	0.003	-0.005**	0.003
Intermediate	-0.005**	0.003	**0.019****	0.010	-0.014**	0.007
Upper secondary	-0.005**	0.003	-0.014**	0.007	**0.019****	0.010

Source: Own calculations based on SOEP waves 1991-2009 and BIBB Transistion Survey 2006.
Notes: Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A3.7: School reform: effect of the reduced years on the probability to obtain the upper secondary degree, men

	Expected earnings with an upper sec. degree		Upper sec. degree	
	Before the reform	Additional after reform	Baseline %	Increase of %
All	621,774	30,422	37%	8.5%-points
Low educated background	621,729	30,339	24%	6.1%-points
Intermediate school	613,673	30,112	15%	13.6%-points

Source: Estimations based on BIBB Transition Study 2006 and SOEP, waves 1991-2009.
Notes: To calculate the lifetime earnings I used annual earnings from labor of people observed working who are not older than 45 years.

Table A3.8: School reform: effect of the reduced years on the probability to obtain the upper secondary degree, women

	Expected earnings with an upper sec. degree		Upper sec. degree	
	Before the reform	Additional after reform	Baseline %	Increase of %
All	504,733	26,195	47 %	4.2%-p.
Low educated background	504,124	26,107	35 %	5.0%-p.
Intermediate school	502,056	26,133	21 %	8.1%-´p.

Source: Estimations based on BIBB Transition Study 2006 and SOEP, waves 1991-2009.
Notes: To calculate the lifetime earnings I used annual earnings from labor of people observed working who are older than 45 years.

Chapter 4

The treatment effect of attending a high-quality school and the influence of unobservables[††]

4.1 Introduction

Many countries pursue a schooling policy in which children (sometimes at very early age) are segregated into school tracks with very different educational ambitions. As a result, children in such school systems often find themselves sorted into a group of students with high or low average academic merits. Naturally, both economic researchers and policy makers are interested in understanding the effects that this tracking has on the child's future educational career and later labor market outcomes.

In Germany, the case studied here, children are separated into different types of secondary school at the age of 10. The school types differ with respect to their level of academic ambitions, curriculum and years to receive a degree. Three main types of schools can be distinguished at this stage, following Dustmann et al. (2012) we will simply denote them as high, middle or low quality schools.[50] The selection into these different schools is based on a system in which teachers recommend an appropriate school form for the child according to an evaluation of academic merit. However, the system has been shown to im-

[††]This chapter is based on joint work with Ronny Freier from DIW Berlin, see Freier and Storck (2012).

[50]For further details see the section on the institutional background in Germany, section 3.3.

plicitly take other factors into account, including for example, the educational ambitions of the parents.[51] Once the decision is made, children will mostly remain with that school type for 4-5 years before they have a chance to up- or downgrade between schools. During that time, students at the high-quality school study among high-achieving peers, they have better educated and better paid teachers and are subject to a more stringent curriculum.

This paper studies the effect of attending a high-quality school between the ages of 10 and 15 on future educational outcomes. For the analysis, we combine individual data on children and their parents from the German Socio-Economic Panel (SOEP) with administrative data on school supply at the regional level. In the SOEP, we track students between the age of 10-12 and observe their secondary school choice. We then follow the same children through the age of 16-17, when they are being surveyed on their self-assessed future educational pathway. In the paper, we will focus on two particular outcomes: (1) the self-reported intention to finish the *Abitur*, which is the entrance certificate for university (2) the intention to seek university education.

The main challenge in evaluating the causal effect of attending the high-quality secondary school is the inherent endogeneity in school choice. To overcome this problem, researchers have applied methods such as regression control frameworks as well as program evaluation techniques such as instrumental variable estimation. Using detailed control variables at the individual and household levels, we highlight the results of simple regression control estimates. Moreover, we have information on local school supply and we instrument individual school attendance with these regional information. Specifically, we use local supply as an instrument in two different ways: (1) a dummy variable that indicates whether the town has a high-quality school within its borders and (2) a variable for the share of high-quality school positions in all secondary schooling within the county.

Methodologically, we then explicitly test for the influence of unobserved factors both in the OLS framework and in the instrumental variable estimation. Here, we apply the new technique proposed by Altonji et al. (2005b).[52] In this method, we draw conclusions on the potential bias from selection on unobservables by carefully examining the selection on the observable characteristics.

[51] Also the recommendations are not always binding such that parents can challenge the initial recommendation and see to it that their child will be placed in a better school.

[52] Note that the initial paper only develops the method for the regression control framework. In an additional paper, the same authors also adjust their new technique to validate instrumental variable approaches (Altonji et al., 2005a).

Our findings highlight that unobservables may indeed play a crucial role in the evaluation of the treatment effect of interest. While the traditional regression control and instrumental variable techniques signal a large positive and significant effect of attending a high-quality school, the new method by Altonji et al. (2005b) points to the fact that even a modest degree of selection on unobservables (relative to selection on observables) suffices to explain away the entire effect. This finding may be hardly surprising for the case of the regression control framework (even with detailed and relevant controls), however, the influence of unobservables is also potentially large in our instrumental variable design.

With this analysis, the paper contributes to four main strands of literature. First, we add to the literature on school quality. A number of papers for the U.S. have found large and consistent effects of attending (private) catholic schools, which are often substantially better than public schools (see Evans and Schwab (1995), Neal (1997), Altonji et al. (2005b)). For Germany, Dustmann et al. (2012) provide an analysis similar to ours in which they use a different instrument (school entry age at the cut-off rule). They report no significant long-run gains from attending a high-quality school, a result that is not inconsistent with our findings.

Secondly, our paper also speaks to the literature on peer effects. In evaluating the effect of attending a high-quality school, we implicitly draw the attention to the potential mechanism of peer effects. Here, we can compare our results to a large body of research that addresses the effects of children's peers (f.ex. Ammermueller and Pischke (2009), Bifulco et al. (2011), Schneeweis and Winter-Ebmer (2007)).

Knowledge about the magnitude of peer effects on educational achievement is highly relevant, especially in a system of separated schools. Hence, in a third stream of literature the effect of peer composition on a students achievements is of interest. Depending on the school track, the composition of peers differs widely. The benefit of attending a high-quality school could be twofold. Students benefit not just from higher qualified teachers and a more stringent curriculum but also from more ambitious peers. This is especially true for students who are at the margin of attending a high-quality school, a better peer group can have a significant impact on educational achievements.

Finally, our paper provides valuable insights for the rich literature that is concern with using proximity to educational institutions. Here, researchers have both been interested to study the direct effect of distance to institutions

of education (Frenette (2006), Spiess and Wrohlich (2010), Denzler and Wolter (2011)) as well as the possibilities to use those variables as instruments (Card, 1995). Our findings confirm the recent critic on the use of those variables (Altonji et al., 2005a) and the potential problems due to the influence of unobservable characteristics. A more detailed review of the literature will follow in the next section.

The remaining part of the paper is structured as follows. After this introduction and the survey of the relevant literature, section 4.3 discusses the empirical methodology. Then, we introduce our data and give descriptive statistics in section 4.4. Section 4.5 provides our empirical findings. Section 4.6 concludes the analysis.

4.2 Literature

This section reviews the related literature. As mentioned above, the analysis aims to contribute to four main strands of literature. Below, we illustrate how the paper relates to the literature of school quality, to studies of the effects of peers, the system of school tracking, as well as to the body of work concerned with proximity to educational institutions.

For the U.S., a number of studies are concerned with the effects of attending (private) catholic schools. Compared to the public school systems, catholic schools often provide better quality education. Naturally, researchers are interested in analyzing the quantitative effect that this quality difference has on educational outcomes and wages. Evans and Schwab (1995) estimate the effect on the probability of finishing high school as well as starting university. To account for the endogeneity of attending a catholic school they apply an instrumental variable approach based on catholic religion of the family and having a catholic school close by. They find an effect of attending a catholic school of about 13 percentage points on high school graduation and university attendance rates. Neal (1997) uses a very similar instrumental variable approach but additionally evaluates the effects of attending a catholic school on university graduation rates and wages. He finds that the positive effect of catholic school attendance is mainly driven by the effect it has on urban minorities.

The papers by Altonji et al. (2005a,b) take a second look at the effect of school quality related to catholic schools. In Altonji et al. (2005b) the authors develop a technique (AET technique in the following) based on the idea that the amount of selection on the observed explanatory variables in a model provides

a guide to the amount of selection on unobservables (see 4.3.3). Applying the new method they support the earlier findings that catholic school attendance has a significant effect on subsequent educational outcomes. In Altonji et al. (2005a), the authors apply the new method also to check the validity of the instruments used by Evans and Schwab (1995) and Neal (1997). They find, that these instrumental variable approaches are prone to significant bias from unobservables. Both papers directly relate to our study also in terms of the methodology.

For Germany, Dustmann et al. (2012) provide an analysis similar to ours in which they evaluate the effect of attending a high-quality secondary school. They use a different instrument in which they make use of the school entry cut-off rule. Based on this rule, children will enter elementary school at different ages (up to 11 months difference) which can be shown to significantly affect the probability of attending a high-quality secondary school on longterm outcomes. They report no significant gains from attending a high-quality school. Without controlling for selection into the types of school, they find that students attending a high-quality school at age 14 are 50 percent more likely to obtain the *Abitur* (German university entrance diploma) than students attending a middle-quality school at age 14. Further, the first group earns at least 10 percent higher wages. However, when applying an IV-strategy to account for selection into the school types, attending a more a high-quality school has little effect on school type completed, education completed and wages.

Our paper also speaks to the literature on peer effects and the effect of tracking. The starting point for the explanation of peer effects is the assumption that children not only learn from their teachers but from class-and schoolmates, too. The peer group is an important source of motivation and aspiration (Schneeweis and Winter-Ebmer (2007)). Most studies on peer effects find significant effects of peer-group composition on educational achievements (Lavy et al. (2012), Vardardottir (2012), Ammermueller and Pischke (2009), Gould et al. (2009), Schneeweis and Winter-Ebmer (2007), Hoxby (2000)).

In our setting, thus, students are exposed to different peers because they are tracked into different school types. The results of studies that estimate the effect of tracking on educational outcomes are mixed. Brunello and Checchi (2007) find positive effects of the tracking system on a students performance using constraints on educational participation, such as financial constraints or family reasons as an instrumental variable. Hanushek and Wössmann (2006) match international primary school tests to secondary school tests and compare

differences in test scores across countries. They find that early tracking has no clear impact on the students average achievements. Our study contributes to this stream of literature by asking the question if students who are at the margin of being tracked to a high-quality school benefit from the more academic environment.

Finally, our study is related to the literature on proximity to educational institutions. In a seminal paper, Card (1995) uses the distance to the next university to instrument the years of schooling in a Mincer-type wage regression. Since then, many studies have taken a similar approach to instrument schooling variables (Denzler and Wolter (2011), Frenette (2009), Frenette (2006), Evans and Schwab (1995), Neal (1997)). As mentioned above, we should point out that the use of proximity as an instrument has recently been criticized. (see Altonji et al. (2005a)).

Moreover, researchers are also interested in analyzing the direct effect of proximity on attending a certain educational institution. For example, Spiess and Wrohlich (2010) estimate the effect the proximity to a university and find that a 10 kilometer decrease in the distance to a university, increases the probability to enrol in higher education by 2-3 percentage points. Similarly, Falch et al. (2011) and Virtanen and Väänänen (2010) ask for the effect of distance on the probability of attending a university or a school with specific professional track in Norway and Finland.

4.3 Empirical model and methodology

4.3.1 Identification problem and regression-control framework

The focus of this paper is to estimate the relationship between attending a high-quality school and subsequent education outcomes. Denote the outcome with Y_i for individual i. In this study, we mainly use two binary indicator variables as outcomes. We have information whether a student (at the age 16/17) plans to finish the *Abitur* and whether she intends to continue with post-secondary, university education.

Further denote the treatment variable with D_i. This variable indicates whether a child attended a high-quality school between the age of 10 - 15. Consider the following simple OLS model:

$$Y_i = \beta_0 + \beta_1 D_i + X_i\beta + \epsilon_i \tag{4.1}$$

$$D_i = \gamma_0 + X_i\gamma + \vartheta_i \tag{4.2}$$

Eq. 4.1 represents the outcome equation in which β_1 estimates the effect of treatment on the education attainment. An additional set of controls is captured in X_i. Eq. 4.2 describes the selection process into treatment.

In the OLS framework, the parameter β_1 can only be consistently estimated under the restrictive conditional independence assumption (conditional on the observables). This implies that $E[D \cdot \epsilon] = 0$. Alternatively, the assumption can be illustrated to mean that $\rho = 0$ in the joint distribution of the errors:

$$\begin{bmatrix} \epsilon \\ \vartheta \end{bmatrix} \sim \mathcal{N}\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_\epsilon & \rho \\ \rho & \sigma_\vartheta \end{bmatrix} \right) \tag{4.3}$$

Estimating only the OLS model in eq., 4.1 the coefficient on D would have a causal interpretation if the conditional independence assumption strictly holds. While we are in a position to control for a detailed set of variables both on the level of the family and the child (see section 4.4), we are concerned that our application of the regression control framework suffers from omitted variable bias.

Specifically, we consider it likely that omitted variables (in ϑ_i) that present a positive shock in the selection equation are also positively associated in the outcome equation (hence, in ϵ_i). Our main concern is, thus, a upward bias of the effect of high-quality school attendance on subsequent school outcomes. As an example, the ambitions of parents concerning their child´s education can not be observed, but, might positively affect the selection into a high-quality school as well as later school outcomes.

We pursue two strategies to tackle this identification issue. Firstly, we apply an instrumental variable approach in which we instrument the decision to attend a high-quality school with the local supply of these schools. Secondly, we use the new method of Altonji et al. (2005b) and Altonji et al. (2005a) to test the sensitivity of our estimates to omitted variable bias (see section 4.3.3).[53]

[53]Note that the initial application of the Altonji et al. (2005b) method is very similar to our research question. They evaluate the causal effect of attending a catholic high-school on graduation rates and university attendance. Thus, the method is, while generally applicable, specifically useful in our context.

4.3.2 Instrumental variable estimation

To overcome the omitted variable bias issue in the identification of the treatment effect, we first consider an instrumental variable estimation. Consider a similar system of equation as in eq. 4.1 and eq. 4.2, except that we now also include an instrument Z in the selection equation:

$$Y_i = \beta_0 + \beta_1 D_i + X_i\beta + \epsilon_i \tag{4.4}$$

$$D_i = \gamma_0 + X_i\gamma + Z_i\delta + \vartheta_i \tag{4.5}$$

For any variable to be a candidate for Z (the instrument), two conditions must be fulfilled. Firstly, the instrument variable must be a strong predictor of treatment in eq. 4.5, $E[D \cdot Z] \neq 0$. Given our treatment, we are, thus, looking for a variable that significantly shifts the probability of attending a high-quality secondary school. The second condition is that the variable can be excluded from the outcome eq. 4.4, $E[\epsilon_i \cdot Z] = 0$.

In our application, we follow a large literature that suggests to use local school supply as an instrument for attending a high-quality school. Specifically, we have two measures for the local availability of an upper secondary high school. First, we coded a dummy variable that indicates whether a high-quality school is situated directly in the municipality where the child lives at the time the school decision is made (see further description in section 4.4). Secondly, we can use the share of children in a county that is offered a spot in a high-quality school as an instrument for the individual uptake.

The identifying assumption for those instruments to be valid are the following. Firstly, the instruments must be a relevant factor in determining the decision to attend a high-quality school. Here the argument is that transportation costs will have an effect. Parents (and teachers who make the recommendations) tend to favor local schooling and children in towns with a local high-quality school are more likely to attend those institutions. The relevance of our instruments can be tested in the first stage of the 2SLS estimation.

The second assumption is that the instruments are exogenous to unobservable characteristics in the outcome equation. In our case, we would be particularly concerned if parents strategically locate with regard to the supply of such high-quality schools. For the US, we know that location decisions are strongly affected by the local quality of the school (see Black (1999), Bayer et al. (2007)). However, in the context of Germany, we are, *ex ante*, less worried that

choice of location is endogenous. Other than in the US, school finances and school quality are not depended on housing values. Thus, the wealthiness of the area that a family lives in does not determine the availability of a high-quality schools.

In general, the independence assumption for the IV is not directly testable. However, similar to the case of OLS, we can use the method by Altonji et al. (2005b,a) to study the sensitivity of the IV estimates to selection on unobservables. Relying on the assumption that selection on unobservables is equal to selection on observables, we can evaluate the validity of the IV strategy.

4.3.3 Sensitivity of the OLS effect, bias estimation and IV validity

As argued above, the estimate of the OLS estimation cannot be given a causal interpretation due to potential omitted variable bias. Similarly, IV estimates could be biased if the instrument is likely to pick up the effect of unobservables. Altonji et al. (2005b) developed a new method to assess the magnitude of this bias. In the following, we shortly introduce their method (building on their exposition) for the case of OLS.

Altonji et al. (2005b) start from the sensitivity test that was initially proposed by Rosenbaum (1995). Rosenbaum suggests taking the equations, like in eq. 4.1 and 4.2, and model the parameter ρ explicitly. While the OLS would set $\rho = 0$ by assumption, we could vary ρ in the band between zero and one. Thereby, we would give structure to the covariance pattern between unobservables in the selection and the outcome equation. In varying ρ, we can assess the sensitivity of the outcome coefficient of interest with increasing influence of unobservables.

While this sensitivity analysis could be of interest per se, it remains unclear which value of ρ is appropriate. Altonji et al. (2005b) derive a particular value for ρ under an assumption that they denote *equality of selection on unobservables and observables*. The main idea of their approach is to ask the following question: Given that the independence of unobservables assumption in OLS (or likewise in IV) is likely to be violated, how large would the bias from selection on unobservables be, if that selection is in the same order as the selection on observables.

In their paper, Altonji et al. (2005b) provide an argument why it is reasonable to view the case of equality of selection on unobservables and observables

as a natural upper bound of the bias that is due to selection. In their derivation of the approach, they essentially assume that the set of observables is randomly picked from the full set of variables and that, as a result, the variables that are unobserved explain just as much of the selection as the observed measures. In reality, however, we would expect that survey makers as well as researchers pick observable characteristics that are best suited for the analysis at hand. So, while it will hardly ever be the case that we can assume to have captured all relevant information (independence of unobservables), it is more reasonable to argue that we have managed to include observables in the analysis that explain at least as much as unobservables.

The *equality of selection on unobservables and observables* assumption implies that the following condition holds:

$$\rho_{AET} = \frac{Cov(\epsilon, D)}{Var(\epsilon)} = \frac{Cov(X\beta, D)}{Var(X\beta)} \tag{4.6}$$

To the right of this equation is the relationship between treatment and the index of observables (normalized by the size of the variance in that index). That relationship is equated to be the same as the relationship between treatment and the unobservable part that determines outcome. This assumption makes it possible to obtain an estimate for the only fundamentally unobservable part $Cov(\epsilon, D)$ (all three other parts can be estimated).

Now, the fact that we can assess the size of $Cov(\epsilon, D)$ (under equality of selection) can directly be used to estimate the bias in the OLS. Denote $\tilde{D}$, where the tilde indicates that this variable is the residual of a regression of D on all X. For OLS, we know:

$$plim\hat{\beta}_{1OLS} = \beta_1 + \frac{Cov(\epsilon, \tilde{D})}{Var(\tilde{D})} \tag{4.7}$$

Now, note that $Cov(\epsilon, \tilde{D}) = Cov(\epsilon, D)$ as ϵ and X are orthogonal. Thus, we know the expression of the bias in the OLS and we can substitute in from equation 4.6:

$$\frac{Cov(\epsilon, D)}{Var(\tilde{D})} = \frac{Cov(X\beta, D)}{Var(X\beta)} \frac{Var(\epsilon)}{Var(\tilde{D})} \tag{4.8}$$

We can estimate this expression with the following procedure. We first estimate a OLS model of the outcome on all X (excluding the treatment). From this regression, we get the measure of $Var(\epsilon)$, which is the variance in the outcome that cannot be explained by our observed control variables. Also,

this regression gives us the predicted values, $X\hat{\beta}$. In the next step, we use this predicted index of observables and regress it on our treatment variable, D. The coefficient on the predicted index in that regression gives us the term, $\frac{Cov(X\beta,D)}{Var(X\beta)}$. To compute the implied bias, we finally need an estimate of the term, $Var(\tilde{D})$. For that, we regress treatment on all X and obtain the variance of the residual. Based on those three components, we can now calculate what the implied bias in our OLS estimation would be under the assumption of equality of selection on unobservables and observables.

Altonji et al. (2005b) also suggest computing the ratio of the main OLS treatment effect divided by the implied bias. This ratio, then, measures how strong the selection on unobservables would have to be (relative to selection on observables) to explain the entire OLS treatment effect. If, e.g., the ratio is 2, selection on unobservables would need to be 2 times stronger as selection on observables to account for the full estimated effect.

A similar procedure can also be used to assess the IV validity. The IV assumption is $E[\epsilon_i \cdot Z] = 0$, which specifies that the instrumental variable does not correlate with unobserved factors in the outcome equation. In Altonji et al. (2005a), the authors adjust the above procedure to test this IV assumption. The equality of selection on unobservables and observables assumption then yields:

$$\frac{Cov(\epsilon, Z)}{Var(\epsilon)} = \frac{Cov(X\beta, Z)}{Var(X\beta)} \tag{4.9}$$

Again, this condition can be used to assess the impact of correlation of the instrument with unobservables under the condition that this relationship is similar to the correlation of the instrument with observable characteristics. Similar to above, this information can then be used to estimate the implied bias in the IV estimation by using the following bias formula:

$$plim\hat{\beta}_{1IV} = \beta_1 + \frac{Cov(\epsilon, \tilde{Z})}{\lambda Var(\tilde{Z})} \tag{4.10}$$

where λ is the first stage estimate in the 2SLS procedure.

4.4 Data and descriptive statistics

In this paper, we mainly rely on data from the German Socio-Economic Panel (SOEP). The SOEP is a yearly representative panel survey that gathers detailed information on the socio-economic background of currently more than 21,000

persons living in approximately 12,000 households across Germany. The survey started in 1984 and the most recent available wave is from 2010.

For the analysis, we sample young students aged 16-17 from the SOEP households. At this age, the SOEP provides a specific youth questionnaire[54] in which information on past schooling, the student' attitudes towards school and further education as well as occupational plans are collected. For all individuals that answered this survey, we then track them back in time to the point at which they made the relevant schooling decision (the transfer from elementary school to secondary school) at the age between 10 and 12 (see section 3.3).[55] Our final sample contains 2,679 young adults.

Our sampling period is through 1992 and 2010. The specific youth survey was first introduced in 1999. Thus, we observe the first respondents of this survey to have made their schooling choices in 1992. We then use all available waves of the SOEP until 2010. Table A4.1 shows how our sample is composed over time and by the age at which we observe the initial schooling decision.

We consider two outcome variables, both of which are measured in the youth questionnaire at age 16-17. Our first measure of interest is the respondent's self-assessed intention to finish the *Abitur* which serves as a university entrance degree in the German education system (see 3.3). We code a dummy variable if students plan to finish this degree in the future.[56] The second educational measure that we use is a similar dummy on the intention to continue education at the university level. Here, the young adults are asked how they assess the likelihood that they will continue schooling at the university level.[57]

[54]At the age of 16-17 it is the first time in the SOEP that the young adults are interviewed personally. Before that interview all information on these young adults are provided by the household head in the household survey.

[55]The ages 10-12 is when those schooling decisions are typically made. In our data, we can also track the majority of children in the SOEP households back to that time. However, for a smaller group of children, we can only track them back to when they were 13 or even 14. We still use the information from those children in the analysis, with the additional assumption that their initial schooling choice at the age of 10-12 was identical to the one we observe when they are 13-14. We believe that this assumption is not critical as transfers from one school type to another is infrequent at these ages.

[56]The questions from which we code this variable are as follows: First, students are asked whether they intend to finish any educational degree in the future. If that question is answered yes, they have to indicate the exact educational degree they plan to obtain. We code the dummy variable as one, if they answer yes to the first question and state that they hope to obtain the *Abitur*.

[57]Naturally, we would like to use actual educational attainment at the end of the children's school period. Unfortunately, the SOEP allows us to observe only 1200 kids from age 10, when they make their school choice, through the age of 21, by when they should have finished their school secondary education. This data base proofs too little to estimate the effect of high-quality school attendance on secondary education outcome. To that end, we cannot

Our treatment variable is whether a child (age 10-12) attends a high-quality school (*Gymnasium*). We obtain this information from the household surveys (answered by the parents) at the relevant age. Overall, only 33 percent of the children obtained a spot at this highest school track. In total, there are about 2800 such schools in Germany, a number that has been decreasing slightly over our sampling period (see Figure A4.2).[58]

In Table 4.1 we highlight the descriptive relationship between attending a high-quality school (treatment) and the subjective educational chances (outcomes). On average, just over 50 percent of all young adults answer positively to the question whether they intend to finish the *Abitur*. It is important for our study that not only students who attend a *Gymnasium* after elementary school can pursue schooling to the *Abitur* but also a relevant share of students from other school types is able to earn the highest school degree, as described in 3.3. Still, separated by the specific school track, the difference in the preference for obtaining the *Abitur* or entering university is enormous (89 percent for children in the high-quality schools versus just about 33 in the remaining school types).[59] The picture is similar for the subjective probability to continue a university education. For a significantly smaller sample, we can also assess who indeed finished the *Abitur*. We find a very similar pattern there.[60]

The advantage of using the SOEP data is that we can include a rich set of control variables in the analysis. We have information both on the level of the students as well as on the level of the household that they belong to. For the students, we know the gender, the number of siblings as well as the initial recommendation for secondary school by the teachers. The last variable is an especially important determinant of school choice and can be used as a proxy for child ability. On the household level, we control for the parents' nationality, both parents' educational attainment, household income as well as information on how much parents cared about school related issues. In Table

compare our results to the findings in Dustmann et al. (2012). As new waves are added to the SOEP, such an analysis will become feasible.

[58]The slight drop in Figure A4.2 in the appendix is entirely driven by the demographic development in Germany's former eastern parts. Here, the post reunification drop in the number of children required a significant number of school closures. That drop, however, is partially off set by a modest increase in the number of schools in the former western parts.

[59]The preference for *Abitur* and university education of students who do not attend a high-quality school is mainly driven by students from a middle-qualifying school. Only 12 (11) percent of low-quality school students intend to earn the *Abitur* (enter university education). In our later estimation we also estimated the models excluding low-quality students. Because of the small sample size we can not find significant results, thus (results available on request.)

[60]The coefficient of correlation between the intention to finish the *Abitur* and actually earning the degree is 0.69.

Table 4.1: Descriptives: educational outcomes by school type attended

	Intention to		Actual
	finish *Abitur*	start university	finished *Abitur*
Full sample	51.51	40.09	40.43
By school attendance:			
High-quality school	89.01	71.30	78.88
No high-quality school	32.79	24.51	23.97

Source: Own calculations based on SOEP data.
Notes: The table illustrates the descriptive relationship between our treatment variable and the outcomes in our analysis. We show the share of young adults that answer our outcome variables positively in the entire sample as well as by the attendance status in a high-quality school.

A4.2, we present descriptive statistics for all control variables by treatment status. Additional to those individual or household level controls, we include state (and sometimes county level) fixed effects as well as fixed effects for cohorts.

To apply our proposed IV strategies, we combine the individual level information on school attendance, school outcomes and other personal characteristics with data on local school supply across Germany. Using the regional information in the SOEP, we can link the local supply of schools within a municipality or county to the individual child's precise location at the age of the school decision. Data on the local school supply have been collected from different databases of the statistical offices of the states.[61]

We use two different variables as instruments in our analysis. The first is an indicator variable that takes the value one if the municipality that a child of relevant age lives in has a high-quality school within its borders. Overall, there are 14,445 municipalities (as of 1997) in Germany. About 20 percent of those towns have a high-quality school available locally. Figure A4.3 illustrates how high-quality schools are divided by the distribution of population size. While it is generally true that larger towns have a much greater probability to have a locally available high-quality school, we observe considerable variation in the sizes of towns. In Figure A4.4, we also highlight the geographical dispersion (for the state of Bavaria). The graph indicates that for children in municipalities

[61] Data on county level education measures are available from the database called "Statistik regional" available from state statistical offices. Information on municipal level schools was more difficult to obtain. Here, we collected current and past lists of all *Gymnasiums* from each federal state that included the actual school address. Based on this information, we manually coded the schools into the municipalities.

without a high-quality school travel time might indeed be substantial. To address population differences, we include the number of inhabitants of the town as a control in the regression.

In Table A4.4, we show how the descriptive statistics of our control variables vary with this first instrument. We observe about 2/3 of all children in municipalities with a locally available high-quality school (a fact that is very much driven by the larger towns). Control variables between the two groups vary only slightly. Children with a positive IV have slightly more educated parents and their parents are more often foreign born. Also the recommendation for secondary school is more often for a high-quality school. Differences in the descriptive statistics of our control variables by the instrument are notably smaller than the differences by treatment status (see Table A4.2).

Our second candidate variable for an IV is the share of students in grade 7 (in all students in grade 7) that are attending a high-quality school within a county. In Figure A4.5, we show a map of all German counties (436 in 1997) and in which quartile of the distribution the county falls. The dispersion of locally available high-quality school positions is very large. In the data, we indeed have counties in which no spots for high-quality schools are directly available, while other counties can offer as much as 60 percent of their children a position at a high-quality school. The graph also illustrates that there is considerable variation between states, which formally carry the responsibility for school policy.

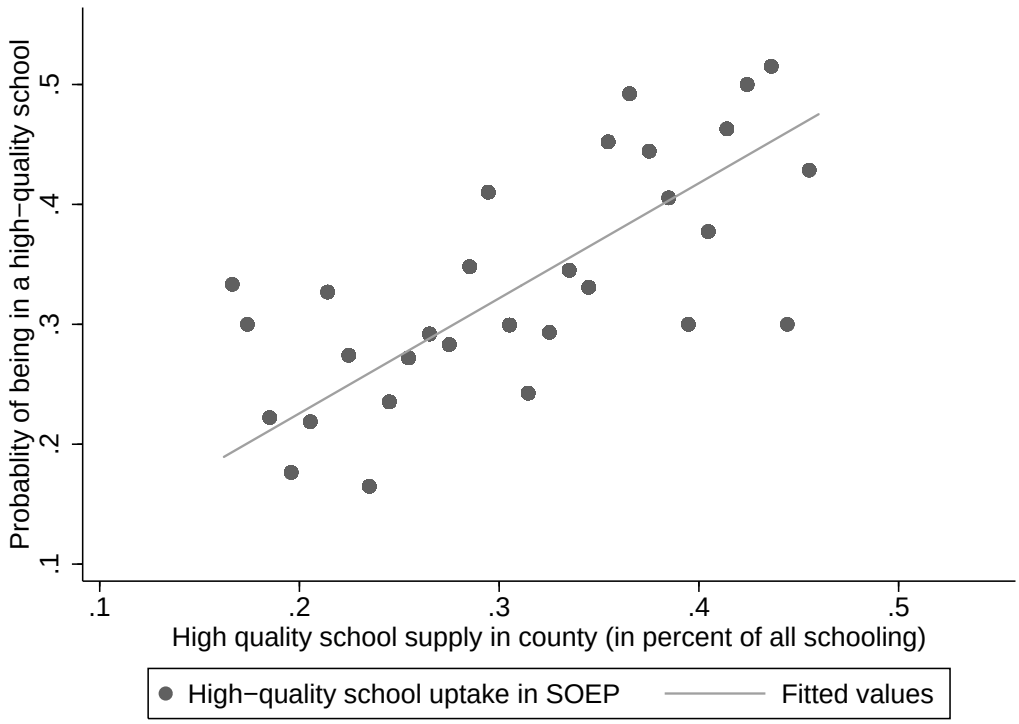
Table 4.2: High-quality school take up: by IV

	Parents w/ high-quality education			Parents socio-economic status	
	None	One	Both	Low	High
Municipality					
w/o high-quality school	0.19	0.41	0.63	0.16	0.37
w high-quality school	0.26	0.57	0.76	0.25	0.52
County					
low high-quality school supply	0.19	0.43	0.74	0.15	0.38
medium high-quality school supply	0.23	0.49	0.61	0.21	0.45
high high-quality school supply	0.28	0.57	0.82	0.27	0.55

Source: Own calculations based on SOEP data.
Notes: Low socio-economic status: ISEI score below 43 (out of 90). The ISEI score is a standardized international socio-economic index of occupational status.

Does local availability actually determine whether children attend a high-

Figure 4.1: Probability of high-quality school take up by local school supply



Source: Own calculations.

Notes: This figure graphically illustrates the relationship between the local availability of high-quality schools and the actual take up rate in the SOEP data. The horinzontal axis represents the percentage of all students in a county that can go to a high-quality school (versus schools of lower quality). We correlate those data against the observed take up rates of children in the SOEP. For that exercise, we track SOEP children into the counties that they where living in at the age of the school choice. Each point represents a bin of one percentage point in the x-variable and the average take-up rate within this bin. We excluded bins below 16 and above 46 because sample size in those bins would have been to low (we mostly observe only one or two observations in those bins). The imposed line is fitted from a simple bivariate regression.

quality school? In theory, school attendance could still be equally distributed independent of the local availability if children commute to other municipalities or counties. Figure 4.1 correlates the measure for the local supply within a county with the actual take-up rates in the SOEP. While there is variation around the trend, we observe a clear positive relationship between local supply and actual attendance. Similarly, Table 4.2 shows that our instruments are relevant in the determination of the actual schooling decision. Irrespective of the parent's education or socio-economic status, the probability of observing a child attending a high-quality school is always higher in a town with a locally

available school or in a county with a higher share of locally supplied positions.

4.5 Results and discussion

We present the results of our estimation and testing in two parts. First, we highlight and discuss the results from the regression control framework. We show the main results of the OLS estimation, discuss several checks for robustness and test for potential omitted variable bias using the AET method. Secondly, we illustrate the results of the IV estimations. Apart from the main results, we present reduced form and first stage results, applying the AET method also here; this time to evaluate the validity of the IV approach.

4.5.1 Regression control framework

The main results of the OLS estimations are presented in Table A4.3. Columns 1-3 present the estimation results for our first outcome variable: the intention to finish the *Abitur*. Columns 4-6 show the estimates for the outcome of whether the student plans to start a university education. In columns 1 and 4, we highlight the pure descriptive OLS effect using our treatment as a binary explanatory variable (the results correspond to the descriptives in Table 4.1). In columns 2 and 4, we include our rich set of control variables and in the final columns we also specify state and cohort fixed effects.

Our treatment variable of whether a child attended a high-quality school is positive and significant for both outcomes and throughout all specifications. The effect on finishing the *Abitur* is as large as 56% in the pure difference. The number drops to about half once we control for our additional set of explanatory variables. However, it remains a sizable positive effect where attending a high-quality school changes the probability of planning to finish the *Abitur* by 28 percentage points. For the intention to start a university education, we report a similarly large estimate with about 22 percentage points.

Throughout all models, we find that the coefficients on the control variables fall in line with our expectations. We find that, female students are more likely to report plans for continued education, number of siblings has a negative effect, while parents education and household income exert a positive effect. Interestingly, whether parents show an interest in school issues is negatively related to both outcomes, indicating that parents get more involved if the children have problems. The most important variable for our outcome is the recommendation for a high-quality school, which is shown to be highly relevant

for both outcomes.[62]

In Table A4.6, we test variations of our models and further specifications. We evaluate how the estimates change if you estimate a probit model instead, include the local population number in the regression, use county fixed effects instead of state fixed effects, use data for the former West only and reweight the sample using SOEP sampling weights.

Before we investigate the sensitivity of the OLS estimates to the influence of unobservable variables, we want to return to Table A4.2. Here, we show descriptive statistics for our control variables by treatment status. The reported differences are often large and significant between the two samples. E.g., a child that has two parents with an *Abitur* is more likely to attend a high-quality school while children with foreign parents are observed in the treatment status less often. Thus, from observing the correlation between observables and the treatment variable we have little doubt that the OLS estimates are also potentially prone to influence by unobservables.

Table 4.3: Amount of selection on unobservables relative to selection on observables required to attribute the entire high-quality school effect to selection bias

	$\frac{\widehat{cov}(X'\beta, D)}{\widehat{var}(X'\beta)} \div$	$\widehat{var}(\epsilon)$	$\frac{\widehat{cov}(\epsilon, D)}{\widehat{var}(\epsilon)} \div$	$\widehat{var}(\widetilde{D})$	Implied bias	Ratio
	(1)	(2)	(3)	(4)	(5)	(6)
Intention to						
			Panel A. Full set of observables			
Finish *Abitur*	1.04	0.16	0.17	0.12	1.47	0.19
Start university	1.17	0.18	0.21	0.12	1.83	0.15
			Panel B. Restricted set of observables			
Finish *Abitur*	0.57	0.16	0.093	0.12	0.8	0.36
Start university	0.62	0.23	0.14	0.12	1.22	0.18

Source: Own calculations based on SOEP data.
Notes: For the restricted set of observables the variable teachers' recommendation has been eliminated from the set of observable using the Frisch-Waugh-Lovell-Theorem.

This observation is confirmed when we implement the AET method to check for the potential influence of unobservable characteristics. The results for this method are reported in Table 4.3. We report all stages of the calculation, as introduced above (see section 4.3.3). In the interpretation, we focus on the last two columns. In column 5, we report the implied bias. We find that the

[62]Note that this is also the only variable that matters immensely for the point estimate of our treatment variable. Leaving this variable out of the regression control framework, we observe significantly larger treatment effects.

bias, calculated under the assumption of equality of selection on observables and unobservables is very large. Indeed, it is multiple times larger than our estimated coefficient in the OLS (being 28 (22) percentage point for our first (second) outcome). This is also indicated by the final column 6 in which we divide the coefficient from the OLS regression by the implied bias. This ratio has the following interpretation: Given the implied bias, selection on unobservables would need to be only 1/5 (0.19) as strong as selection on observables to explain away the entire effect in the OLS. We, thus, have to consider it quite likely that the estimates in the regression control framework are indeed flawed by omitted variable bias.

Note that the implied bias itself should not be interpreted too strictly. This bias is calculated under the arguably strict assumption that selection on unobservables is in the same order as selection on observables. As Altonji et al. (2005a) argue themselves, this assumption really serves as an upper bound of the influence of unobservables and the actual degree is likely to fall short of that.

In panel 2 of Table 4.3 we follow another recommendation of Altonji et al. (2005a) and exclude the secondary school recommendation from the set of observables when we apply the AET method.[63] We do this, because the recommendation variable is unique in its influence on both treatment and outcomes. If we exclude this variable in the AET method, the results improve slightly, however, the OLS results are still likely to be significantly biased due to unobservable characteristics.

4.5.2 Instrumental variable estimation

In this section, we first highlight the results of the reduced form and the first stage for our two instrumental variables. In panel A of Table 4.4 we show the estimates when we include the instruments (instead of the treatment) in the outcome equation. If the instruments are meaningful, we expect positive and significant estimates in this reduced form. In column 1, we show the results for including our first instrument of whether a municipality has a local high-quality school within town borders. In the second column, we test our second instrument which is the share of school positions in high-quality schooling within a

[63] In practice, we first run a regression of all variables on the recommendation variable and then rerun the AET method with the residuals from those regressions. In their paper, Altonji et al. (2005a) suggest treating isolated variables in this specific way, if they present especially important variable in the determination of both treatment and outcome.

county. Finally, columns 3 and 4 show the estimates when we include both instruments simultaneously. We find sizable and significant effect for our first instrument on both outcomes. For our second instruments, the reduced form effect is not as strong and only sometimes significant.

Panel B of the same table shows the results of the first stage in the 2SLS estimation. We find that the local supply of high-quality schooling are important predictors of the attendance of such a school. Both instruments are positive and significant at the 5% level when included in the first stage. The *F-statistic* on the instruments is well above 10 and the *Hansen J statistic* (when we include both instruments) signals that our instruments can indeed be excluded from the outcome equation. Note that, all reduced form and first stage regressions include the full set of additional control variables.

Table 4.4: Reduced form and first-stage of the instrumental variable approach

	IV1	IV2	IV1 & IV2	
			IV1	IV2
	(1)	(2)	(3)	(4)
	Panel A. Reduced Form			
Intention to finish *Abitur*	0.036**	0.089	0.038**	0.012
	(0.018)	(0.120)	(0.019)	(0.127)
Intention to finish a university education	0.050***	0.254**	0.037*	0.167
	(0.018)	(0.123)	(0.020)	(0.130)
	Panel B. First stage			
High-quality school attendance at age 14	0.072***	0.359***	0.066***	0.237**
	(0.013)	(0.087)	(0.014)	(0.093)
Personal characteristics	Yes	Yes	Yes	Yes
Set of state dummies	Yes	Yes	Yes	Yes
Set of cohort dummies	Yes	Yes	Yes	Yes
F-value of instruments	24.90	11.36	15.98	
R^2	0.010	0.004	0.013	
Hansen J statistic: Finishing *Abitur*			0.362	
p-value			(0.548)	
Hansen J statistic: Starting university			0.205	
p-value			(0.651)	

Source: Own calculations based on SOEP data.
Notes: (***/**/*): indicates significance at the 1%- / 5%- / 10%-level. Robust standard errors in parentheses.

The main results of the IV approaches are presented in Table A4.5. We show the results of the two outcome variables in columns 1-3 and 4-6 respectively. At the top of the table, we indicate whether we use our first instrument, our second instrument or both. All 2SLS estimations include the full set of additional

controls. For the results in column 2 and 5 it must be kept in mind the reduced form and the first-stage diagnostics point to a weak instrument problem. This is also indicated by the higher standard errors when using the second IV.

The results for the treatment effects in the 2SLS are positive and mostly significant. For the intention to finish the *Abitur*, we find point estimates that range between 29 and 49 percentage points. The results are significant at the 5% level when we include our first IV, but insignificant when only the second IV is included (this corresponds directly to the results in the reduced form, see Table 4.4). This estimates are notably larger than our finding for OLS. This is also true for the second outcome variable which is the stated preference to continue post-secondary education at a university. Here, our significant point estimates range between 58 to 75 percentage points.

Overall, the IV strategies give highly significant and strongly positive results. Also the reduced form and first stage estimates speak in favor of the analysis. However, we find the size of the IV estimates to be implausibly large. The arguments in the literature have mostly pointed to an upward-bias of the OLS due to omitted variables such as the child's true ability or the motivation of the parents, hence, an even larger effect of the IV estimates is surprising.

How could those large IV estimates be reconciled?[64] One argument could be that the nature of the instrument leads to a very specific local average treatment effect (LATE) that is being estimated. The presented instruments estimate a LATE that will effectively compare the marginally treated to those that are marginally non-treated. In terms of the expected peer effects from attending a high-quality school, one could argue that the marginally treated have the most to gain from attending one, while those that are marginally non-treated have the most to lose. However, we find it hard to believe that this could explain such a large positive difference with the transition from the OLS to the IV. To investigate this issue further, we continue to carefully test for bias in the IV estimation that may explain the large effects.

Before we test for the validity of the instrument using the AET method, we again draw the attention to the simple comparison of means in Table A4.4. Similar to above, we here show the characteristics of our observed variables,

[64] In the literature on the effect of schooling on earnings, the finding that IV-estimates are larger than estimates from OLS is a common pattern. Researchers usually argue that the smaller effect measured in OLS stems from measurement error in the explanatory variable. In most studies this variable is years of education and the information is asked retrospectively. For our explanatory variable, a child´s attendance at a high-quality school, a significant measurement error is unlikely.

this time, by the two categories of our first instrument. If the assumptions is to hold that our instruments are independent of unobservables, we should expect little to no correlation of the instrument with our observables. While it is true that our instrument varies much less with the observables than the treatment variable (see Table A4.2), we still find some significant differences. Our instrument varies significantly with parent's education as well as parent's nationality, which is worrisome for our analysis.

Table 4.5: IV Estimation: Amount of selection on unobservables relative to selection on observables required to attribute the entire high-quality school effect to selectionbias

	$\frac{\widehat{cov}(X'\beta, Z)}{\widehat{var}(X'\beta)}\div$	$\widehat{var}(\epsilon)$	$\frac{\widehat{cov}(\epsilon, Z)}{\widehat{var}(\epsilon)}\div$	λ	$\widehat{var}(\widetilde{Z})$	Implied bias	Ratio
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intention to							
			Panel A. IV 1				
Finish *Abitur*	0.21	0.16	0.03	0.08	0.20	2.18	0.22
Start university	0.23	0.18	0.04	0.08	0.20	2.59	0.25
			Panel B. IV 2				
Abitur	0.03	0.16	0.00	0.34	0.01	2.71	0.18
Start university	0.03	0.18	0.01	0.34	0.01	3.08	0.18

Source: Own calculations based on SOEP data.

The AET method formalizes this test and evaluates the validity of the instrument under the assumption that selection on the unobservables is equal to selection on observables. The results of this test are shown in Table 4.5. Again, we present every step of the derivation. For interpretation, we focus on column 6. We find that our instruments can not pass the test and that the implied bias calculated by the AET method exceeds the point estimates of the IV regressions. The degree to which our instruments vary with the observed factors is still too large to plausibly argue that a correlation of the instrument with unobserved characteristics would not be influential.

How can this finding be explained? Comparing column 1 of Table 4.5 to the same column of Table 4.3, we see that the correlation of the instrument with the index of observables is much less than the correlation of treatment with that index. However, in the bias formulation of the IV, we also have to divide by the first stage estimates (see eq. 4.10). Even if the instruments show less correlation with the observables, the implied bias in the IV estimation is

inflated by the small first stage estimate and ends up being even bigger than in the OLS.

In the end, the AET method highlights that both the OLS and the IV are prone to bias due to selection on unobservables in the application at hand. This result hinges on the strict assumption that we can learn about the implied bias induced by unobservables by carefully analysing how treatment (or the instrument) relate to the observable characteristics. If we would observe no or little correlation here, we would have reason to argue that the influence of unobservables is unlikely to affect the results. However, we observe significant correlation between the observables and both our treatment and instruments.

4.6 Conclusion

This paper studies the effect of attending a high-quality secondary school on further educational outcomes. The specific focus of the paper is on the potential influence of selection on unobservables that is likely to affect the estimation of the treatment effect. Methodologically, we first use regression-control framework as well as instrumental variable techniques. We then carefully evaluate the influence of unobservable characteristics in both methods using the technique proposed by Altonji et al. (2005b,a). This methodology draws conclusion based on the assumption of equality of selection on observables and unobservables.

The analysis is based on an extended database that connects information of the SOEP with administrative data of local school supply in a municipality and/or the county. We observe children at the age of 10-12 when they make their secondary school choice and are able to follow them through the age of 16-17 when they self-assess their future educational plans. Specifically, we can investigate the treatment effect of attending a high-quality school on the self-reported intention to finish the *Abitur* as well as the intend to seek post-secondary, university education

In the first part of the empirical results, we analyze the effect of attending a high-quality school in a regression-control framework. Using detailed control variables at the individual and household levels, we report very large and significantly positive effects of the treatment. However, these large effects are then shown to be potentially driven by selection on unobservables. The AET method indicates that even a modest degree of selection of unobservables (relative to selection on the observables) would suffice to explain away the entire effect. These results clearly highlight why researchers are sceptical of using

simple OLS techniques to address this research question.

In the second part, we turn to instrumental variable approaches in which we instrument high-quality school attendance with the local supply of such schools. Specifically, we collect data on (1) an indicator whether the child's home town has a high-quality school within town borders and (2) a variable for the share of high-quality school positions within the local county. Results of the instrumental variable estimations also point us to large and significant treatment effects of attending a high-quality school. Moreover, traditional first stage diagnostics as well as the reduced form estimations show that the first instrument is relevant, while the second instrument is prone to be a weak instrument

However, even in the instrumental variable approach we fail to pass the test provided by the AET method. When we evaluate the validity of the IV approaches using this method, we again detect excessive correlation of the instrument with observable characteristics that leads us to the conclusion that an important bias from unobservables cannot be ruled out. This is a surprising result given that a large literature is interested both on the direct effects of proximity to educational institutions as well as on the use of such variables as instruments. Even if this type of instrumental variables has recently been criticized.

Finally, in terms of policy relevance we should carefully avoid to draw the wrong conclusions from our results. We can only highlight that conventional methods and our instrumental variables approaches are prone to bias from selection on unobservables. That does not imply that the bias from omitted variables cannot in fact be very small and that attending a high-quality school still has a positive and large effect on further educational outcomes. However, to prove such a causal relationship, further research is needed.

4.7 Appendix

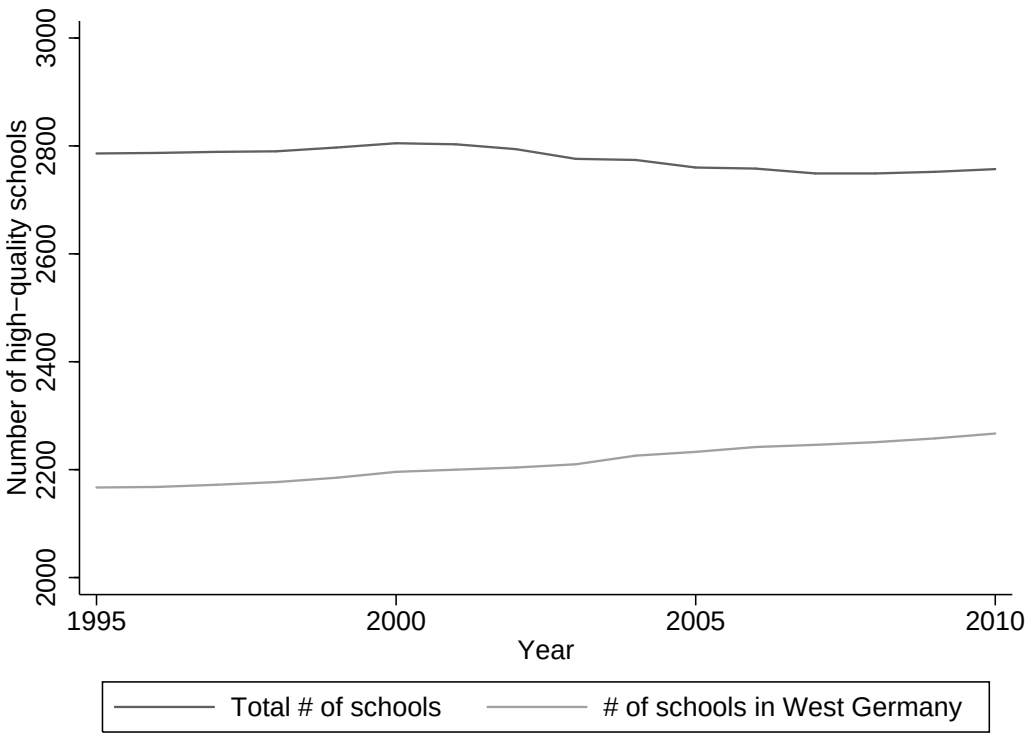
4.7.A Tables and figures

Table A4.1: Age and year of observation

		Year of observation		
Age	Total	1992-1996	1997-2001	2002-2007
8	2	0	2	0
9	61	22	34	5
10	657	218	298	141
11	868	219	406	243
12	655	73	387	195
13	246	8	172	66
14	190	0	131	59
Total	2,679	540	1,430	709

Source: Own calculations based on SOEP data.
Notes: The table shows the composition of the sample over time and by the age at which we observe the child with her initial schooling decision.

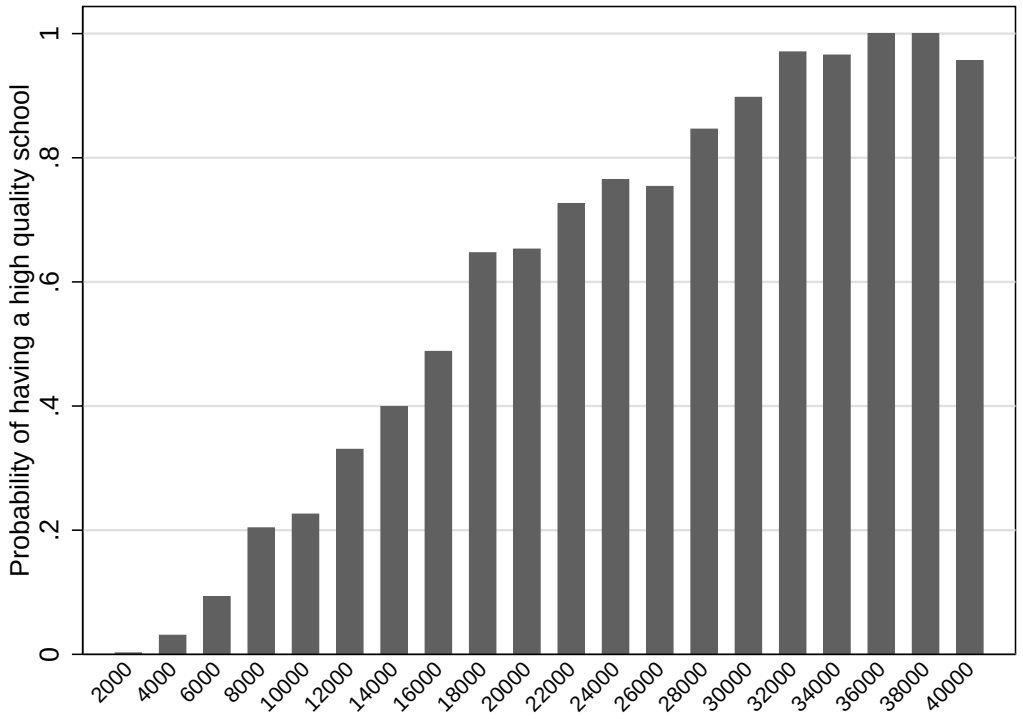
Figure A4.2: Number of high-quality schools over time



Source: Own calculations based on data from "Statistik Regional"

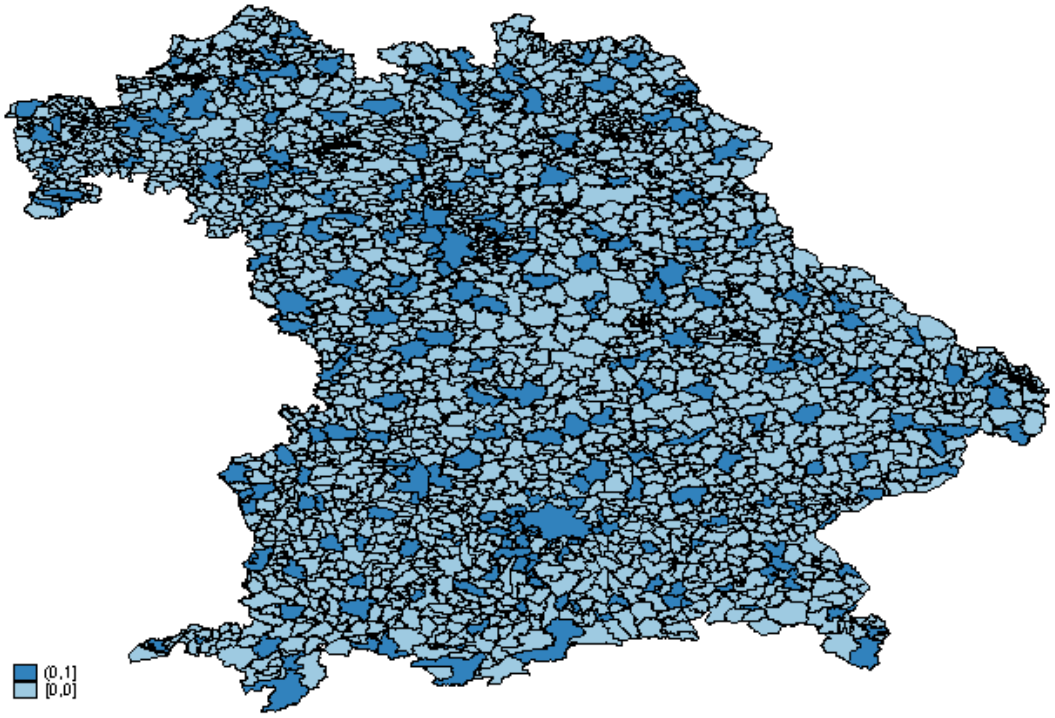
Notes: In this figure, we highlight the development in the number of high-quality schools in Germany for the time period between 1995 and 2010. The upper line shows the total number of high-quality schools in each respective year. The lower line illustrates the development within the West of Germany.

Figure A4.3: Probability of observing a local high-quality school by population size categories



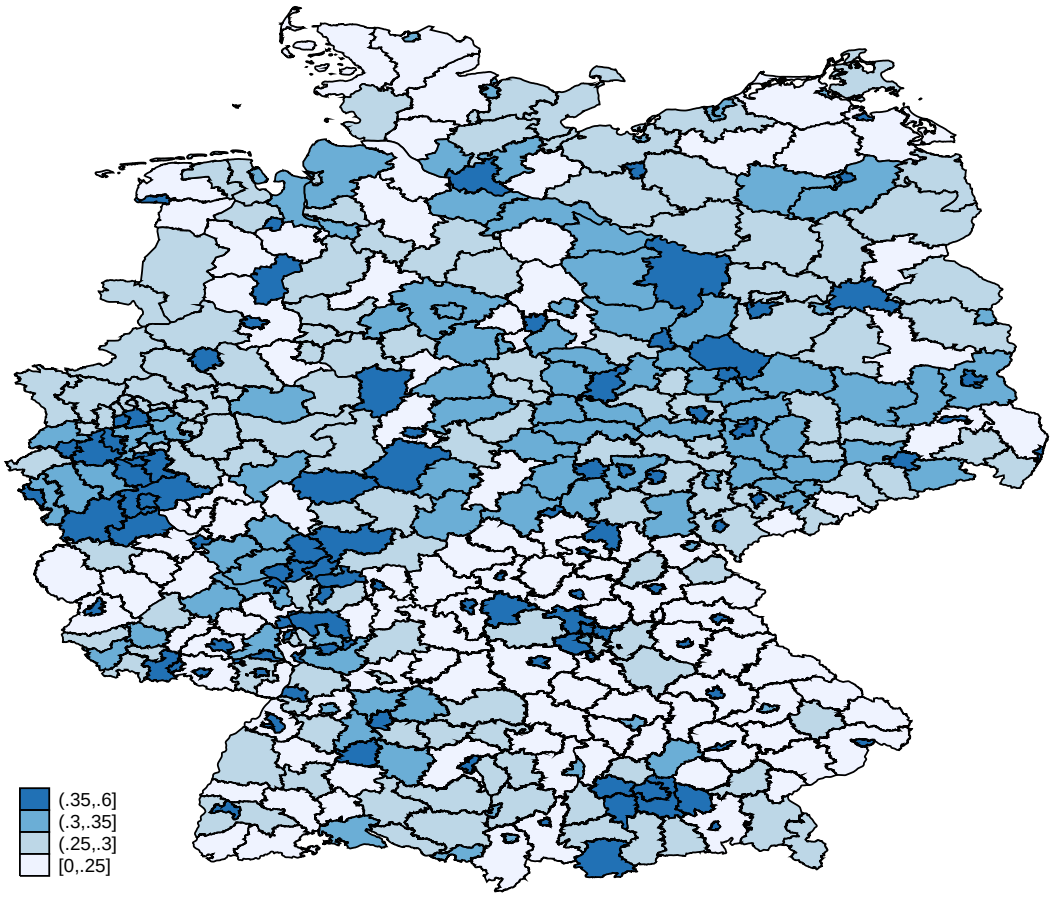
Source: Own calculation based on data from "Statistik Regional" and own collection.
Notes: This figure shows the probability of observing a local high-quality school by the distribution of municipal population size. We grouped the data in bins of 2000 inhabitants (the labeling in the graphs shows the upper limit of each bin). On the y-axis we then plot the probability within each bin that town of that size have local high-quality school available. The data are taken from the year 1997. For this graph, we exclude municipalities larger than 40,000 inhabitants as there is no variation above that threshold.

Figure A4.4: Location of high-quality schools in Bavaria (1997)



Source: Own calculations based on data from "Statistik Regional" and own collection.
Notes: The graph highlights the variation that we have in our first instrument, a dummy indicator whether a town has a high-quality school locally available. For clarity, we only show municipalities from the state of Bavaria in the year 1997. The towns in the darker scale have a *Gymnasium* within town borders.

Figure A4.5: Share of high-quality school attendees (by county in 1997)



Source: Own calculations based on data from "Statistik Regional" and own collection.
Notes: This graph shows the variation in our second instrument. Here, we use difference in the share of students (in all students) that can obtain a high-quality school placement in a specific county. In the graph, we highlight all 436 counties as of 1997. We separated the data roughly in four quartils going from white (0-25 percent of the students), to dimlight blue (25-30 percent), to light blue (30-35 percent) to dark blue (35 or more percent).

Table A4.2: Descriptive statistics by high-quality school take-up

	High-quality school attendance					
	no		yes			
Total # of obs	1732		864			
	Share	S.E	Share	S.E	Diff.	T-test
Female	0.47	0.50	0.54	0.50	-0.074***	-3.56
Parents w/ high-quality education						
None	0.80	0.40	0.48	0.50	0.32***	17.41
One	0.13	0.34	0.27	0.45	-0.14***	-8.91
Both	0.05	0.21	0.23	0.42	-0.19***	-14.94
Missing	0.02	0.14	0.01	0.11	0.009	1.54
Socio-Economic Status (isei score)						
Low	0.46	0.50	0.24	0.43	0.22***	11.10
High	0.42	0.49	0.72	0.45	-0.30***	-14.94
Missing	0.12	0.33	0.04	0.21	0.08***	6.43
Parents´s nationality						
None foreign	0.82	0.39	0.92	0.27	-0.10***	-6.93
One foreign	0.04	0.20	0.05	0.21	-0.00	-0.15
Both foreign	0.12	0.33	0.03	0.16	0.10***	8.16
Missing	0.02	0.13	0.01	0.10	0.01	1.42
Number of Siblings						
Zero	0.26	0.44	0.26	0.44	-0.00	-0.25
One or two	0.65	0.48	0.68	0.47	-0.03	-1.60
More than two	0.10	0.29	0.06	0.24	0.04**	3.15
Recommendation for secondary school						
Lower-quality school	0.57	0.50	0.09	0.28	0.48***	26.37
High-quality school	0.13	0.34	0.79	0.41	-0.66***	-43.43
No recommendation	0.20	0.40	0.05	0.22	0.15***	10.35
Missing	0.10	0.30	0.08	0.27	0.03*	2.08
Parents care about school						
Not so much	0.23	0.42	0.26	0.44	-0.03	-1.76
Very much	0.77	0.42	0.74	0.44	0.03	1.76
Household Income (mean in Euro)	2377	1187	3233	1735	-868.1***	-14.41

Source: Own calculations based on SOEP data.
Notes: Low socio-economic status: ISEI score below 43 (out of 90). The ISEI score is a standardized international socio-economic index of occupational status.

Table A4.3: Main OLS results

	Dependent variable: Intention to finish *Abitur*			Dependent variable: Intention to start a university education		
	OLS	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
High-quality school attendance	0.56***	0.28***	0.28***	0.47***	0.22***	0.22***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
Female		0.06***	0.06***		0.03*	0.03*
		(0.02)	(0.02)		(0.02)	(0.02)
Recommendation for secondary school						
(Ref.: Lower qualifying school)						
High-quality school		0.33***	0.32***		0.26***	0.26***
		(0.03)	(0.03)		(0.03)	(0.03)
None		-0.01	0.01		-0.02	-0.01
		(0.02)	(0.02)		(0.02)	(0.02)
Missing		0.07**	0.01		0.04	-0.04
		(0.03)	(0.06)		(0.03)	(0.05)
Number of siblings						
(Ref.: Zero)						
One or two		-0.05***	-0.05***		-0.05**	-0.05***
		(0.02)	(0.02)		(0.02)	(0.02)
More than two		-0.08***	-0.09***		-0.06*	-0.07**
		(0.03)	(0.03)		(0.03)	(0.03)
Parent's nationality						
(Ref.: None foreign)						
One foreign		0.01	0.01		0.03	0.02
		(0.04)	(0.04)		(0.04)	(0.04)
Both foreign		-0.02	-0.04		0.03	0.02
		(0.03)	(0.03)		(0.03)	(0.03)
Missing		-0.10	-0.09		-0.00	0.02
		(0.13)	(0.13)		(0.13)	(0.12)
Parents w/ high-quality education						
(Ref.: None)						
One		0.12***	0.12***		0.14***	0.13***
		(0.02)	(0.02)		(0.02)	(0.02)
Both		0.14***	0.13***		0.18***	0.18***
		(0.03)	(0.03)		(0.03)	(0.03)
Missing		0.03	0.01		0.01	-0.01
		(0.11)	(0.12)		(0.10)	(0.10)
Household income		0.02***	0.02***		0.03***	0.03***
		(0.01)	(0.01)		(0.01)	(0.01)
Missing household income		0.12***	0.12***		0.12***	0.11***
		(0.04)	(0.04)		(0.04)	(0.04)
Parents care about school						
(Ref.: Not so much)						
Very much		-0.04**	-0.04**		-0.04**	-0.04*
		(0.02)	(0.02)		(0.02)	(0.02)
Missing		-0.03	-0.01		-0.24**	-0.21*
		(0.15)	(0.14)		(0.11)	(0.11)
Constant	0.33***	0.25***	0.23***	0.25***	0.15***	0.13**
	(0.01)	(0.03)	(0.05)	(0.01)	(0.03)	(0.05)
Set of state/cohort dummies	No	No	Yes	No	No	Yes
N	2679	2679	2679	2679	2679	2679
R2	0.28	0.37	0.39	0.20	0.29	0.30

Source: Own calculations based on SOEP data.
Notes: (***/**/*): indicates significance at the 1%- / 5%- / 10%-level. Robust standard errors in parentheses.

Table A4.4: Descriptive statistics by instrumental variable

	IV1 Municipality					
	w/o high-quality school		w/ high-quality school			
Total # of obs	1048		1548			
	Share	S.E	Share	S.E	Diff.	T-test
Female	0.49	0.50	0.50	0.50	-0.011	-0.55
Parents w/ high-quality education						
None	0.73	0.44	0.67	0.47	0.064***	3.48
One	0.17	0.37	0.19	0.39	-0.019	-1.26
Both	0.08	0.28	0.12	0.33	-0.038**	-3.04
Missing	0.01	0.12	0.02	0.14	-0.007	-1.30
Socio-Economic Status (isei score)						
Low	0.43	0.50	0.36	0.48	0.075***	3.88
High	0.50	0.50	0.53	0.50	-0.031	-1.53
Missing	0.07	0.25	0.12	0.32	-0.045***	-3.80
Parents´s nationality						
None foreign	0.91	0.29	0.81	0.39	0.095***	6.78
One foreign	0.04	0.19	0.05	0.22	-0.012	-1.44
Both foreign	0.05	0.21	0.12	0.32	-0.07***	-6.45
Missing	0.01	0.09	0.02	0.13	-0.01*	-2.24
Number of Siblings						
Zero	0.24	0.43	0.27	0.44	-0.03	-1.73
One or two	0.67	0.47	0.65	0.48	0.02	1.27
More than two	0.09	0.28	0.08	0.27	0.01	0.55
Recommendation for secondary school						
Lower-quality school	0.41	0.49	0.40	0.49	0.01	0.45
High-quality school	0.30	0.46	0.38	0.48	-0.07***	-3.87
No recommendation	0.17	0.38	0.14	0.34	0.03*	2.26
Missing	0.11	0.32	0.08	0.27	0.03**	2.80
Parents care about school						
Not so much	0.25	0.43	0.23	0.42	0.0158	0.93
Very much	0.75	0.43	0.77	0.42	-0.0158	-0.93
Household Income (mean in Euro)	2512	1147	2798	1635	-285.8***	-4.75

Source: Own calculations based on SOEP data.

Notes: Low socio-economic status: ISEI score below 43 (out of 90). The ISEI score is a standardized international socio-economic index of occupational status.

Table A4.5: Main IV results

	Dependent variable: Intention to finish *Abitur*			Dependent variable: Intention to start a university education		
	IV1	IV2	IV1 & IV2	IV1	IV2	IV1 & IV2
	(1)	(2)	(3)	(4)	(5)	(6)
High-quality school attendance	0.49**	0.29	0.45**	0.65***	0.75**	0.58***
	(0.23)	(0.34)	(0.20)	(0.25)	(0.38)	(0.22)
Female	0.06***	0.06***	0.06***	0.02	0.02	0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Recommendation for secondary school						
(Ref.: Lower qualifying school)						
High-quality school	0.20	0.32	0.22*	0.01	-0.06	0.05
	(0.14)	(0.21)	(0.13)	(0.15)	(0.23)	(0.14)
None	0.01	0.01	0.01	-0.02	-0.03	-0.01
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
Missing	-0.03	0.01	-0.02	-0.10	-0.12	-0.09
	(0.06)	(0.07)	(0.06)	(0.07)	(0.08)	(0.07)
Number of siblings						
(Ref.: Zero)						
One or two	-0.05***	-0.05***	-0.05***	-0.05**	-0.05**	-0.05**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
More than two	-0.08**	-0.09***	-0.08**	-0.04	-0.04	-0.05
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)
Parent's nationality						
(Ref.: None foreign)						
One foreign	0.01	0.02	0.02	0.01	0.01	0.02
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)
Both foreign	-0.01	-0.03	-0.02	0.06	0.07	0.05
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Missing	-0.09	-0.04	-0.05	0.08	0.19	0.14
	(0.16)	(0.15)	(0.16)	(0.15)	(0.15)	(0.14)
Parents w/ high-quality education						
(Ref.: None)						
One	0.10***	0.12***	0.10***	0.09***	0.08**	0.10***
	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)
Both	0.09**	0.13**	0.10**	0.10*	0.09	0.11**
	(0.05)	(0.07)	(0.04)	(0.05)	(0.08)	(0.05)
Missing	0.01	-0.03	-0.03	-0.07	-0.17	-0.12
	(0.14)	(0.14)	(0.15)	(0.14)	(0.13)	(0.12)
Household income	0.01	0.02	0.01*	0.02*	0.01	0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Missing household income	0.12***	0.12***	0.12***	0.09**	0.09*	0.10**
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
Parents care about school						
(Ref.: Not so much)						
Very much	-0.04*	-0.03	-0.03	-0.02	-0.02	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Missing	0.00	0.01	0.01	-0.18	-0.17	-0.18
	(0.16)	(0.15)	(0.15)	(0.16)	(0.17)	(0.15)
Constant	0.25***	0.27***	0.26***	0.17***	0.17***	0.17***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Set of state/cohort dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	2605	2592	2521	2605	2592	2521
R2	0.34	0.34	0.35	0.20	0.18	0.23

Source: Own calculations based on SOEP data.
Notes: (***/**/*): indicates significance at the 1%- / 5%- / 10%-level. Robust standard errors in parentheses.

Table A4.6: Robustness: Different specifications of the Regression-control estimation

	Dependent variable: Intention to				
	Probit	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)
Finish *Abitur*	0.351***	0.283***	0.280***	0.257***	0.266***
	(0.026)	(0.025)	(0.024)	(0.029)	(0.028)
Start a university education	0.247***	0.228***	0.219***	0.209***	0.212***
	(0.029)	(0.028)	(0.027)	(0.033)	(0.032)
Personal characteristics	Yes	Yes	Yes	Yes	Yes
Set of state dummies	Yes	Yes	Yes	Yes	Yes
Set of cohort dummies	Yes	Yes	Yes	Yes	Yes
Set of community controls	No	No	No	No	Yes
Population controls	No	Yes	No	No	No
N	2679	2535	2670	2004	2606

Source: Own calculations based on SOEP data.
Notes: (***/**/*): indicates significance at the 1%- / 5%- / 10%-level. Robust standard errors in parentheses. Column 1: Marginal effect of high-quality school attendance on the outcome variables calculated from a probit-model. Column 2: Result from an OLS regression with population size of the community as an additional control. Column 3: Result from an OLS regression with county fixed effects. Column 4: Result from an OLS regression for only the western part of Germany. Column 5: Result from an OLS regression weighted with SOEP sampling weights.

General Conclusions

Main findings and policy implications

17 million of German citizens are currently using educational institutions such as child care, secondary schools, vocational training or universities. The educational system is thus an important part of the structure of our society and determines the course of life and perspectives of many. In this dissertation I quantify the impact of the educational system, educational reforms and monetary benefits from education on a young person's educational choices. The results show that educational policies, as well as labor market outcomes play a significant role in the decision on which final educational level to obtain and where to apply for post-secondary education.

Methodologically, the thesis contributes to the literature on educational choices and outcomes by explicitly considering the educational system a student is exposed to. Further, outcomes of educational choices are considered over the whole life-cycle and standard returns to education are disaggregated by fields and related to their variance. Various datasets and empirical strategies are used to deepen the understanding of educational choices.

Due to the fact that German federal states have the right to determine their own educational policies, the German education system is very diverse and reforms are constantly debated. In the first chapter of this dissertation I analyze the effect of a state-specific higher-education reform, in particular the introduction of tuition fees, on the mobility of university applicants.

The introduction of tuition fees in some federal states led to heated debates among politicians, students and the public. While opponents feared a reduction of the number of university graduates, especially from low-socio economic backgrounds and underlined the tradition of university education as a public good in Germany, proponents highlighted the need for better financing of universities if these are to remain internationally competitive. The exceptional situation that tuition fees were implemented only in some federal states further

stimulated a discussion of whether students will flee the tuition fees and crowd into states without tuition fees. This would increase the financial burden of states without tuition fees, while states with tuition fees would lose important human capital. How the tuition fees would actually alter educational behavior of high-school graduates was hardly foreseeable.

In this dissertation I focus on the mobility aspect of the tuition fees. Although, the reform is evaluated "ex-post" in this dissertation the results could inform the debate on the development of tuition fees across the whole of Germany. The results show an decrease of the probability of university applicants to apply in their home federal state of roughly two percentage points (baseline probability 69%) if the federal state levies tuition fees. The results further show that applicants with better high-school grades react less strongly to the introduction of fees and are more likely to apply in a non-home state regardless of tuition fees. From a state government perspective this implies that the tuition fees carry two distinct advantages. First, tuition fees increase the educational budget of the federal state. Second, they attract applicants with better grades, while only a small share of university applicants are lost to other states.

Against this background, it could be expected that more states introduce fees. The more recent development, though, continued in the opposite direction. Regional elections changed the composition of the state parliaments in three out of the six states with tuition fees. The "conservative party" lost power and the new governments abolished the fees.[65] Now, only two states levy tuition fees. The decision to introduce tuition fees and abolish them again a few years later seems to be driven by the attitude of the different political parties towards the free provision of university education.

Other aspects of the tuition fees are still unclear and leave room for further research. For example, whether universities who charged tuition fees could actually increase educational quality and raise earnings expectations of their graduates or whether a significant share of high-school graduates from low-socio-economic backgrounds actually was discouraged to start university education .

Another eminent characteristic of the German educational landscape is its system of vocational training. Although, governments usually have aimed to increase the share of university graduates, university education might not al-

[65]Baden-Württemberg, Hamburg, North Rhine-Westphalia and Saarland, abolished the fees after the federal parliament changed from being governed by the "conservative party" to coalitions of different parties that object to tuition fees.

ways pay off in the labor market because an education in a similar field can also be pursued in vocational training. A broad literature analyzes the public and private returns to different educational levels and shows that university education in general yields positive returns. As the results in this dissertation indicate, this is not the case for all fields of education. In some fields of vocational training individuals can achieve higher earnings at a given level of risk than achievable in similar fields of university education. This could reflect high demand for vocational education in certain fields and the political aim to increase the share of university graduates might lead to a shortage of skilled employees with a vocational training certificate. Since providing university education is, at least in the short-run, more expensive for the government than vocational training, increasing the share of university graduates in all fields of education might not be an efficient investment of resources.

Only individuals who finished secondary school with an *Abitur* have the choice between vocational training and university education. Hence, the decision about the secondary school degree is of great importance for later labor market outcomes and career opportunities. The three-tier system of Germany's secondary schools suggests that early educational choices can have long-lasting effects on an individual's labor market opportunities. In particular, the lowest level secondary school type (*Hauptschule*) is in the current debate often referred to as a *dead-end*, since possibilities for further education and good job prospects are fairly low. At the same time students who earn the highest school degree can choose between a variety of further educational and occupational paths. The early tracking is often criticized because it determines the educational outcome of a student at a very early age. Obviously, attending a *Gymnasium* after elementary school makes it easier to obtain the *Abitur*, but school transfers and "upgrades" of the degree by continuing schooling are possible and can be taken up by students from other school tracks. Hence, if individuals aim to obtain the optimal level of education, conditional on their abilities, being tracked at a lower level secondary school hampers the probability to earn the *Abitur*, but does not prevent it. How strong the effect of *Gymnasium* attendance is and which additional factors determine the decision to earn the *Abitur* is analyzed in chapters 3 and 4.

In the third chapter I consider policies to induce more students to earn the *Abitur*. I find that a reduction in the numbers of schoolyears before gaining the *Abitur* is likely to increase the share of students who leave school with an *Abitur* because an earlier entrance into the labor market is possible. A further

important fact that emerges is that students who are initially tracked into an intermediate school can be induced to continue schooling to gain the *Abitur*. The reduction of the number of school years to the *Abitur* could therefore increase the number of students who "upgrade" their degree and earn the *Abitur* although they were not tracked into a *Gymnasium* at an early age.

Whether early tracking pre-determines later educational outcomes is further discussed in the last chapter. The results suggest that attending a *Gymnasium* after elementary school strongly influences the preference of a student to earn the *Abitur*. From this it can also be expected that the actual probability to obtain the *Abitur* is several times higher for students at a *Gymnasium* than for students at other tracks. Based on results similar to ours, recommendations are made to integrate the three-tier system into one (or two) school types to eliminate discrepancies in educational opportunities. Based on our results we are sceptical that such an integration would fulfill its goal. Additional tests of our estimates indicates that the positive effect of attending a *Gymnasium* is potentially driven by unobservable factors that cannot be included in the analysis. In that case eliminating the different school types might not be an efficient way to diminish inequalities of education.

Future research

Beyond the contribution made in the chapters of this dissertation several directions for research promise to augment the understanding of educational decision making. The estimation and interpretation of the causal effect of financial incentives on educational choices, in particular, leaves room for continued research. Also, the evolution of earnings in different fields and with different levels of education over time seems to be of academic and public interest.

A choice model that determines how strong prospective students react to changes in earnings expectations or earnings risk when making their decision on which field of education to study could be developed. To estimate the model data from the SOEP could be used. Although this data only allows for aggregated educational field groups, it provides for more possibilities to control for ability, the attitude towards risk and other individual characteristics than data from the Micro Census. The simulation of tax reforms, reforms of the student support system (*Bafoeg*) or further reforms of the tuition fee system could be simulated to see how financial incentives change the composition of graduates in different fields of study.

Further, a lack of information on earning and career possibilities with the different educational levels could be a source of skill mismatch especially for young people from a low socio-economic background. It would be interesting to quantify a skill mismatch based on imperfect information of the young people. Estimates on how information about the benefits of university education or even certain fields of education impact young people's educational choices would be a contribution to scientific research and a valuable information for policy makers. As outlined throughout this dissertation, estimates on the effect of any factor on educational choices are in most cases likely to be biased because of the myriad of unobserved impact factors. An intervention study could be a way to overcome these issues. An experimental type of study that informs a treatment group about the benefits of education, financing schemes and scholarship programmes, while having a control group that does not receive the treatment, could serve as the mean to test hypothesis on the effect of monetary incentives and better information on a young persons educational attainment.

The *G12 reform* that reduced the years to earn the *Abitur* contained the "side effect" that two cohorts of high school graduates left school in the same year. Universities, vocational training programmes and the labor market had to absorb twice as many graduates as usual. Several studies could be interesting in this respect. First, the "double release" of students is likely to have distracted part of the students from university education because they were not able to obtain a spot in their preferred university or were diverted because they expected overcrowd universities. By comparing educational and labor market outcomes of the group who graduated from high school in the years just before the reform with graduates after reform the effect of a supply shock of high educated men and women to the labor market could be estimated. The differences in the time of implementation of the reform across federal states could further serve to identify a causal effect.

If it is true that a higher supply of university graduates decrease educational and earnings opportunities, the effect of a reform that increases educational enrollment through earnings incentives would not hold in the long-run, since earnings would start to fall after the reform. A dynamic model that includes long-run effects would be of need to take this into account. To test the hypothesis that an increase in educational attainment in Germany still increases individual earnings and economical growth determinants could inform politics if a further increase in the level of education is really necessary or if it just leads to an "inflation of degrees" without actually raising the productivity a country.

List of Tables

List of Figures

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Summary

The focus of this thesis is the analysis of educational choices and outcomes at different points in a student's life in Germany. The thesis aims to inform about the determinants of a students educational choices and the outcomes of these choices. Knowledge about these factors is important when thinking about the design of an educational system that gives all students the opportunity to receive the optimal education, conditional on their level of ability.

The first chapter analyzes if students are willing to move from their home federal state to another state to avoid paying tuition fees. Our results show that with the introduction of the state-specific tuition fees the probability of applying for a university in the home state falls by 2 percentage points (baseline: 69 percent) for high-school graduates who come from a state with tuition fees. Moreover, students with (very) good grades have an even higher probability of applying in their home state than they would have had in a scenario without tuition fees, while students with worse grades are more likely to leave. This heterogeneous effect is likely to have consequences for the composition of students in universities and can be valuable for the consideration of the future design and implementation of a tuition fee system.

Chapter 2 compares the monetary benefits of graduating from different fields of education. Positive economic returns to the level of education have been consistently found but not many studies differentiate by field when estimating returns to education. By comparing the returns and the earnings risk of graduating from one of 74 fields of education, we show that not only the level of education is important for later returns but also the chosen field. A longer university education does not always pay off against a shorter vocational training or university of applied science education. Considering earnings risks further suggests that only looking at the average returns does not always give the correct picture on what the most financially attractive educational choice is. The information on the financial returns to fields of education can be an important factor in a prospective students choice of post-secondary education.

Chapter 3 compares estimates of the differences between lifetime earnings of persons with different secondary school degrees and identifies the effect of the earnings expectations on educational choices. A comparison of earnings of a person with a low-qualifying school degree and vocational training as a post-secondary education and a person with a high-qualifying *Abitur* and the same level of post-secondary education indicates that a high value is attached to the *Abitur*. The earnings a student can expect also influences his decision on the chosen degree. As studies on university enrollment have already shown, an increase in expected earnings with a certain degree increases the share of students who obtain that degree. The sensitivity of earnings varies by socio-economic background and by the earlier school attendance of a student. This suggests that the share and composition of school leavers with the *Abitur* could be altered if a reform, as for example the shortening of years of schooling to the *Abitur*, increases the expected lifetime earnings.

How does the attendance of a high-qualifying school type as the *Gymnasium* in Germany affect the later educational decisions of a student? This question will be investigated in the fourth chapter. Applying OLS with many control variables and an instrumental variable approach, we find a significant effect of the attendance on later outcomes. Hence, the estimates suggest that even when comparing assumably *ex ante* equal students, the attendance of a *Gymnasium* increases the probability to enter an academic path later. Possible explanations are the reduced costs of earning the *Abitur* because a transfer to a school that offers the *Abitur* is not necessary but also better and more motivated peers and teachers could be impact factors. To validate our results, we apply a new method by Altonji et al. (2005b) that determines the possible bias of the estimated effect due to unobservable variables. The results from this method indicate that a bias from unobservables is in fact too large as for us to determine with certainty if there is indeed a causal effect of the attendance of a *Gymnasium* on the outcomes of interest.

The last chapter concludes with policy recommendations and ideas for further research.

German Summary

Im Fokus dieser Dissertation steht die Frage nach den Determinanten und Ergebnissen von Bildungsentscheidungen zu verschiedenen Zeitpunkten im Leben von jungen Menschen in Deutschland. Faktoren erkennen zu können, die im Zusammenhang mit diesen Entscheidungen stehen, ist maßgeblich, wenn über die Ausgestaltung eines Bildungssystems nachgedacht wird, das jedem Schüler die Chance geben soll, entsprechend seiner Fähigkeiten den höchsten Bildungsabschluss zu erreichen.

Das erste Kapitel analysiert, ob angehende Studenten bereit sind, das Bundesland zu wechseln, wenn sie dadurch Studiengebühren vermeiden können. Die Ergebnisse zeigen, dass die Einführung von Studiengebühren in nur einigen Bundesländern dazu geführt hat, dass sich die räumliche Mobilität von angehenden Studenten erhöht. Für Studienbewerber aus Ländern, in denen Gebühren eingeführt wurden, fällt die Wahrscheinlichkeit, sich in dem Bundesland für einen Studienplatz zu bewerben, in dem sie ihr Abitur gemacht haben, um zwei Prozentpunkte (Ausgangswahrscheinlichkeit: 69 Prozent). Darüber hinaus wird gezeigt, dass Studenten mit guten Noten eine erhöhte Wahrscheinlichkeit haben, sich trotz Studiengebühren in ihrem Heimatland zu bewerben, während Studienbewerber mit weniger guten Abiturnoten eher den Wohnort wechseln. Dieser heterogene Effekt impliziert mögliche Konsequenzen für die Zusammensetzung von Studenten in den Universitäten und muss bei weiteren Diskussionen um die Ausgestaltung von Studiengebühren berücksichtigt werden.

Kapitel 2 vergleicht den monetären Nutzen von verschiedenen Studien- und Ausbildungsfächern. Positive ökonomische Renditen bezogen auf das Bildungsniveau werden in vielen Studien bestätigt. Wenige Studien jedoch unterscheiden zwischen verschiedenen Bildungsfächern innerhalb eines Niveaus. Mit dem Vergleich von Renditen und Einkommensrisiken von 74 unterschiedlichen fachlichen Abschlüssen zeigen wir, dass nicht nur das Bildungsniveau sondern auch das Fach eine große Rolle für spätere Verdienste spielen. Eine längere

Universitätsausbildung lohnt sich nicht immer gegenüber einer kürzeren beruflichen Ausbildung oder einem Fachhochschulstudium. Betrachtet man zusätzlich das Risiko, das mit den Renditen verbunden ist, ergibt sich, dass der eingeschränkte Blick auf die Renditen nicht immer ein korrektes Bild über die Rangfolge der finanziell anscheinend attraktivsten Fächer abgibt. Informationen über die finanzielle Attraktivität eines Fachs können ein wichtiger Faktor in der Studien- oder Ausbildungswahl von Schülern nach Abschluss der Schule sein und zu einer effizienteren Verteilung von Studenten bzw. Auszubildenden auf die verschiedenen Fächer führen.

Kapitel 3 vergleicht die Unterschiede in dem geschätzten Lebenseinkommen von Personen mit unterschiedlichen Schulabschlüssen und identifiziert den Effekt von Erwartungen über das Einkommen auf die Schulabschlussentscheidung. Das niedrigere Lebenseinkommen von Personen mit einem niedrigen Abschluss und einer beruflichen Ausbildung gegenüber Personen mit Abitur und einem beruflichen Abschluss, weist auf den hohen Wert hin, der mit dem Abitur verbunden ist. Wie andere Studien bereits gezeigt haben, führt ein erhöhter Erwartungswert auf ein späteres Einkommen in einem Beruf mit universitärem Abschluss dazu, dass mehr Personen diesen Abschluss wählen. Meine Ergebnisse zeigen, dass dies auch der Fall für die frühere Entscheidung von jungen Menschen ist, das Abitur zu machen. Darüber hinaus variiert die Sensitivität von Schülern auf eine Veränderung des erwarteten Einkommens mit ihrem sozio-ökonomischen Hintergrund. Aus diesem Grund kann erwartet werden, dass eine Veränderung des erwarteten Lebenseinkommens eines Abiturienten z.B. durch eine Reduktion der Schuljahre hin zum Abitur, den Anteil und die Komposition von Personen mit Abitur verändert. Auf Basis der vorangegangen Ergebnisse wird dieser Effekt simuliert und gezeigt, dass durch die Reduktion der Schuljahre, vor allem Schüler die zunächst kein Gymnasium besuchen, eine erhöhte Wahrscheinlichkeit haben, das Abitur zu erreichen.

Wie beeinflusst der Besuch eines Gymnasiums nach der Grundschule weitere Bildungsentscheidungen eines Schülers in Deutschland? Diese Frage wird im vierten Kapitel dieser Dissertation bearbeitet. Sowohl unter Nutzung der Methode der kleinsten Quadrate mit einer Vielzahl an Kontrollvariablen, als auch mit Instrumentenvariablen, finden wir einen signifikanten Effekt des Gymnasialbesuchs auf spätere Bildungsergebnisse. Das heißt, Schüler mit *ex ante* gleichen Eigenschaften haben eine höhere Wahrscheinlichkeit das Abitur und eine Hochschulausbildung anzustreben, wenn sie nach der Grundschule direkt das Gymnasium besuchen, als Schüler auf einem anderen Schulzweig. Eine

mögliche Erklärung sind die geringeren Kosten des Abiturs, da ein Schulwechsel nicht notwendig ist, aber auch motiviertere Klassenkameraden können eine Rolle spielen. Um unsere Ergebnisse zu bestätigen, nutzen wir eine neue Methode von Altonji et al. (2005b). Hierbei wird determiniert, wie groß eine mögliche Verzerrung des Schätzers durch unbeobachtbare Charakteristika sein müsste, um den gesamten Effekt zu erklären. Die Resultate der Methode zeigen, dass die Verzerrung durch unbeobachtbare Faktoren tatsächlich zu groß ist, um den positiven Effekt eines Gymnasialbesuchs auf unsere Ergebnissvariablen zu belegen.

Das letzte Kapitel fasst die Ergebnisse der Arbeit zusammen und beschreibt Ideen für weiterführende Forschung.

Erklärung gem. §9(4) der Promotionsordnung der Freien Universität Berlin

Hiermit erkläre ich, dass ich meine Dissertation selbstständig verfasst habe.

Johanna Storck