How different are returns to education? Evidence from German school choices[*]

Dörte Dömeland[y]

Universitat Pompeu Fabra

January 2001

This study presents estimates of returns to post-secondary education and wage differentials among graduates from different secondary schools in Germany. I use an empirical model that captures the basic features of the German education system. It controls for selection into post-secondary education and treats latter as endogenous in the wage equation. My results show that OLS estimates are severely biased. The direction of the bias depends on the secondary school type. Annual returns to post-secondary education differ significantly: they are eight times higher for graduates from the highest secondary school than for graduates from the lowest secondary school.

Keywords:education, endogenous switching, wage differentials.

JEL classification:I20, J24, C35.

---

[*]I thank Silvio Rendón for his advice. Antonio Ciccone, J. Ignacio García Pérez, Jaume Garcia, seminar participants at the Universidad de Murcia and of the labor lunch at Universitat Pompeu Fabra provided very helpful comments. Any errors are my own.

[y]Corresponding author. Tel.:+34-93-542-2674; Fax: +34-93-542-1746; dorte.domeland-narvaez@econ.upf.es.

1. Introduction

The German education system provides a unique setup in order to analyze the effect of secondary education on the post-secondary education decision, returns to post-secondary education and wages. In Germany three different types of secondary schools exist. The requirements for obtaining a certain German secondary school degree are relatively homogeneous compared to those of a US high school degree. As a consequence, the type of German secondary school degree obtained provides a rather precise statistic for the level of human capital embodied in an individual. Moreover, a large part of the German population decides to pursue some kind of vocational training. Vocational training is chosen by graduates from all types of secondary schools. Hence, the effect of different secondary school degrees on returns to vocational training can be identified.

In Germany, a student chooses between three types of secondary school: Hauptschule (lower secondary school), Realschule (middle secondary school) and Gymnasium (upper secondary school). After graduating from secondary school he decides whether to invest any further in education or not. His type of secondary school degree plays an important role in this decision, as it affects his training costs in terms of effort and foregone earnings, as well as his comparative advantage e.g. when applying for an apprenticeship or a job. Moreover, it determines his set of post-secondary education choices. University, for example, is usually only accessible to Gymnasium graduates.

Previous estimates of returns to education in Germany have been provided by Knoll and Störck (1993), Winkelmann (1994) and Abraham and Houseman (1993). Their studies concentrate on the change of returns to vocational education during the 80's. They obtain estimates of returns to education by using OLS cross-section regressions between 1984 and 1991 and include dummies for different vocational training choices as well as academic training. Secondary school degrees are either approximated by years of education or by dummies for each secondary school type.

OLS estimation entails three major issues. First, it ignores selection bias in the earnings equation. Latter arises from a truncation of the underlying errors in the earnings equation which results from the fact that educational choices are not randomly assigned across the population. The selection bias can be solved by treating educational choices endogenously in the earnings equation. Second, the German education system suggests, that the unobservables influencing secondary and post-secondary education choice may not be orthogonal. German students usually do not only complete secondary school, but also pursue some post-secondary educational degree in order to reach a specific occupation. Access to this in turn often requires a certain secondary school degree. Hence, students are likely to choose their highest secondary school degree and their post-secondary education simultaneously. This suggests that a simultaneity bias may arise if the secondary school degree is not treated endogenously in the post-secondary education decision. Third, the above approach ignores heterogeneity in returns to education. Ichino and Winter-Ebmer (1999) show that in Germany estimates of annual returns to education vary significantly with subgroups and instruments. Given heterogeneity, instrumental variables provide consistent estimates of the average return to education only under very strong assumptions (see Heckman (1997) and Card (1999)).

The estimates of the average return to post-secondary education in Germany that I present are purged from selection biases and consistent in the presence of heterogeneity of returns to education among graduates from different secondary schools. They are derived by introducing a simultaneous equation model with endogenous dummy variables and switching, which captures the basic features of the German education system. The model accounts for selection into post-secondary education and considers secondary as well as post-secondary education as endogenous variables of the earnings equation.

In this study, I reveal differences in the behavior of post-secondary education choices and in the returns to vocational education among the three secondary school types. I analyze sensitivity of estimates to exogeneity assumptions and present earnings differentials among graduates from different secondary schools. The estimation procedure used is maximum likelihood.

The basic findings are that the three secondary school groups differ in their behavior of choosing post-secondary education, as well as in their returns to vocational training. When loosening the constraint of equal returns to vocational education, OLS reveals that annual returns are more than four times higher for Gymnasium graduates compared to Hauptschule graduates. But this is not the whole story. Endogeneity of secondary school and post-secondary education matters.

Not accounting for endogeneity leads to strong biases. OLS biases returns to vocational education of Hauptschule graduates upward by about 20% and implies a downward bias of more than 60% for Gymnasium graduates. Returns to university are more than twice as high as OLS suggests. Consequently, annual returns to post-secondary education differ significantly: they are eight times higher for graduates from the highest secondary school than for graduates from the lowest secondary school.

The remaining structure of the paper is organized as follows: Next, I provide a short introduction to the German education system. The empirical model is introduced in section 3, followed by the data description. Results are exposed in section 5. A summary and conclusions are offered in the final section.

2. Institutional background

The German education system is characterized by three types of secondary schools and a well-developed vocational training system, which is mainly determined by the apprenticeship. Secondary school types differ in the years of education required to receive the respective final degree, the kind of knowledge provided to the students and the set of possible post-secondary education choices.

Figure 1 illustrates these basic features.

The box on the top of the graph represents Grundschule (grade school). Children enter Grundschule (grade school) at age of six. After four years they are selected into Hauptschule (lower secondary school), Realschule (middle secondary school) or Gymnasium (upper secondary school). The highest level of secondary school the student is allowed to attend depends on his qualifications reached in the fourth grade and the recommendation of the class teacher.

As can be seen in Figure 1, the number of years of schooling which are required in order to obtain the respective final degree increases with the level of secondary school. It takes about 5 years to receive a Hauptschule degree (on the left). A Realschule student needs one year more (in the middle). Usually, a Gymnasium degree (on the right) requires 9 years of schooling.

The types of secondary school do not only differ in years of education but also in the knowledge that is provided to the students. In Hauptschule, students receive fundamental general education which serves as the basis for future vocational training, such as an apprenticeship. The type of education offered in Realschule allows to access higher level jobs. Still, it is more practically oriented than the education taught at a Gymnasium, where the foundations for future academic studies are provided.

Consequently, it is not surprising that the set of post-secondary education choices of graduates from different types of secondary schools is not the same. As Figure

1 shows, only graduates from the upper secondary school can choose to go to university. Furthermore, the time required to complete an apprenticeship takes one year less for Gymnasium graduates.

Insert Figure 1

Figure 1 provides a highly stylized illustration of the German education system.[1] It focuses on the basic and by far most frequented educational tracks. This means that it abstracts from differences among secondary school types which lead to the same final degree (such as Gymnasium or specialized upper secondary schools which are called Fachgymnasium) and subsumes the different post-secondary training choices below vocational training. Similarly, university also includes technical colleges. Graduates from the Gymnasium which accomplished some kind of vocational training before entering university and graduated from university are treated as university graduates. Furthermore, I consider only the highest secondary school degree of an individual. It is this degree which finally determines his set of choices, his probability to continue with post-secondary education and his relative earnings position within a certain group of post-secondary education.

The above mentioned simplifications allow to develop an empirical model which captures the basic features of the German education system: Individuals are selected into three types of qualitatively different secondary schools and then choose whether

[1] In reality, a big variety of schooling and post-secondary training choices exists and the number of possible educational sequences is huge. Winkelmann (1994) identifies 45 distinct training sequences in his sample. A more detailed description of German post-secondary education choices can be found in Appendix 1.

to perform some kind of post-secondary education or not. The set of post-secondary education choices differs among the three groups, but the option to perform vocational training is feasible for all secondary school graduates. The latter allows to identify differences in the returns to post-secondary education among graduates from different types of secondary schools.

3. The Model

A simultaneous equation model with discrete choices translates the stylized German education system, as presented in Figure 1, into an empirical model. A discrete choice model is used as secondary school and post-secondary education are described by degrees rather than years of education. This is adequate for the German education system. First, using years of education may not be appropriate within countries in which years of high school graduation depend on the student's post-secondary education choice (see Card (1999)). Second, the variable years of schooling does not capture the qualitative differences between the three types of secondary school. It does not make sense to state that the difference between a Gymnasium degree and a Realschule degree is three times higher than the difference between a Realschule degree and a Hauptschule degree.[2] Third, approximating the level of education by years leads to measurement errors. For example, a student who graduates from Realschule and completes an apprenticeship invests the same

[2] Recall that it takes five years of secondary school to receive a Hauptschule degree. To graduate from a Realschule (Gymnasium) requires one additional year (four additional years).

number of years in education than a Gymnasium graduate.

The model consists of three types of equations: the secondary school equation (dependent variable S^*); the post-secondary education equation (dependent variable V^*) and the earnings equation (dependent variable w).

Insert Figure 2

The indices in the latter two equations refer to the individual's type of secondary school degree. H, R and G denote Hauptschule, Realschule and Gymnasium respectively.

As can be seen in Figure 2, the model is a so called switching model. The secondary school degree selects each individual into one of three groups. Conditional on his group the individual decides whether to continue with post-secondary education or not and which kind of post-secondary education to pursue. The secondary school degree also determines to which earnings group he belongs to.

In what follows, I will first present the equations, then address estimation and finally discuss the model's basic assumptions and features.

The secondary school equation describes the German secondary school system. Corresponding to the three types of secondary schools that exist in Germany the observed dependent variable ”secondary school degree” S assumes three values. Under the assumption that secondary school levels are ordered from 0 to 2 in ascending order, the secondary school equation can be written as

$$S^* = \beta_s' x_s + u_s \tag{1}$$

with

$$\text{Hauptschule}: S = 0 \text{ iff } S^* \leq 0$$
$$\text{Realschule}: S = 1 \text{ iff } 0 < S^* \leq c_s$$
$$\text{Gymnasium}: S = 2 \text{ iff } c_s < S^*$$
$$u_s \sim N(0; 1)$$

S denotes the level of secondary education and takes the values 0 (Hauptschule), 1 (Realschule) and 2 (Gymnasium). S^* is a latent variable. It describes the "desired" level of secondary education. The vector x_s contains information concerning the educational background of the parents. c_s is a threshold to be estimated. Normalization of the first threshold to 0 allows to include a constant term in x_s. u_s is assumed to be normally distributed with zero mean and unit variance, which permits to identify the threshold c_s.

As Hauptschule and Realschule graduates only face the choice of whether to perform vocational training or not their post-secondary education equation can be described by means of a probit model. It is given by

$$V_i^* = \beta_i' x_i + u_i \tag{2}$$

with

$$\text{No vocational training}: V_i = 0 \text{ iff } V_i^* \leq 0$$
$$\text{Vocational training}: V_i = 1 \text{ iff } V_i^* > 0$$
$$u_i \sim N(0; 1)$$
$$i = H; R$$

where H refers to Hauptschule and R to Realschule.

Again, V_i^* is a latent variable. The level of vocational education actually chosen is V_i. 0 is assigned to no vocational education and 1 to vocational training. Parental background variables are included in x_i. u_i has a unit variance. This assumption is not required, but as V_i^* is not observable, β_i is identified only proportional to the standard deviation of the error term.

Gymnasium graduates face the additional choice of going to university. Consequently, their post secondary education equation is written as an ordered probit such that

$$V_G^* = \beta_G' x_G + u_G \tag{3}$$

with

$$\begin{aligned}
\text{No vocational training} &: V_G = 0 \text{ iff } V_G^* \leq 0 \\
\text{Vocational training} &: V_G = 1 \text{ iff } 0 < V_G^* \leq c_G \\
\text{University} &: V_G = 2 \text{ iff } c_G < V_G^* \\
u_G &\sim N(0,1)
\end{aligned}$$

V_G^* is a latent variable and the level of vocational education actually chosen is V_G. It takes the values 0 (no vocational education), 1 (vocational training) and 2 (university). x_G consists of vocational background variables of the parents and c_G is to be estimated. Identification requires to impose a variance equal to 1 on u_G.[3]

The last equation in this model is the earnings equation. It is characterized by the fact that it contains the endogenous dummy variable V_i and that its error terms are allowed to be correlated with the error of the secondary school equation. The

[3] The decision about post-secondary education does of course not only depend on the type of secondary school degree but also on expected earnings. The right variable to consider here would be the present discounted value of after tax earnings less the costs of post-secondary education. As this variable cannot be calculated and the before tax earnings of a particular year are not the appropriate measure, I do not include any variable explaining differences in earnings in equations 2 and 3. However, I use other variables which are reasonably expected to have affected the decision of which kind of post-secondary education to pursue, such as parental background variables.

earnings equation is written as

$$w_i = \delta_{wi} V_i + \beta'_{wi} x_{wi} + u_{wi}, \; i = H, R, G \qquad (4)$$

with $u_{wi} \sim N(0, \sigma_{wi})$. H, R and G refer to Hauptschule, Realschule and Gymnasium respectively.

In the case of Realschule and Hauptschule graduates, V_i is a dummy variable as defined in equation 2. For graduates from the Gymnasium, the dummy variable V is determined by equation 3 and decomposed into a variable vector $(\delta^V_{wG}, \delta^U_{wG})$. δ^V_{wG} indicates that the Gymnasium graduate completed a vocational training program, while δ^U_{wG} takes value 1 if he went to university.

The vector $(u_s, u_H, u_R, u_G, u_{wH}, u_{wR}, u_{wG})$ is assumed to consist of joint normal random variables with a finite covariance matrix and to be independent of X_s, X_i and X_{wi} with $i = H, R, G$. Of the 28 different elements of the covariances matrix four variances are set equal to one, nine covariances (σ_{sH}, σ_{sR}, σ_{sG}, σ_{HwH}, σ_{RwR}, σ_{GwG}, σ_{swH}, σ_{swR}, σ_{swG}) and the variances of the three earnings equations are estimated. Twelve elements are not identified. This arises from the fact that V_H, V_R and V_G cannot be observed simultaneously for a given individual . Similarly, this is true for w_H, w_R and w_G. As a consequence, the sample observations cannot reflect the respective correlations and the corresponding covariances do not appear in the likelihood function.

The model is estimated by maximum likelihood. Under the assumption of joint normality this yields consistent and asymptotic efficient estimates.

The likelihood function consists of seven contributions or states. There are two states each for Hauptschule and Realschule graduates (no vocational training, vocational training) and three states for Gymnasium graduates (no vocational training, vocational training and university). The sum of the logs of the seven likelihood contributions constitutes the loglikehood function L^* of the entire system that is

$$L^* = \sum_{i=1}^{7} \ln(L_i)$$

To describe the estimation procedure, I present the likelihood contribution of an individual in state four (Realschule with vocational training). Let u_{wR}, u_R and u_S be the residuals in the earnings equation, post-secondary education equation and school equation respectively of a Realschule graduate for given parameter values and log monthly earnings. This likelihood contribution can be written as

$$\begin{aligned} L_4 &= f(u_{wR})P(S=1, V=1|u_{wR}) \\ &= f(u_{wR}) \int_{-X_S\beta_S}^{c_S - X_S\beta_S} \int_{-\infty}^{-X_R\beta_R} f(u_S, u_R|u_{wR})du_S du_R \\ &= f(u_{wR})\Big(\int_{-\infty}^{-X_R\beta_R} \int_{-\infty}^{c_S - X_S\beta_S} f(u_S, u_R|u_{wR})du_S du_R \\ &\quad - \int_{-\infty}^{-X_R\beta_R} \int_{-\infty}^{-X_S\beta_S} f(u_S, u_R|u_{wR})du_S du_R\Big) \end{aligned} \tag{5}$$

with variance covariance matrix $\Sigma_{1R} = \begin{bmatrix} 1 & -\sigma_{sR} & \sigma_{swR} \\ -\sigma_{sR} & 1 & -\sigma_{RwR} \\ \sigma_{swR} & -\sigma_{RwR} & \sigma_{wRwR} \end{bmatrix}$

As can be seen from equation 5, $P(S=1, V=1|u_{wR})$ consists of two conditional probabilities which are again bivariate normal. Hence, they can be transformed to standard normal bivariate cumulative probability functions.

This parametric switching model neither restricts the coefficients among the post-secondary education equations nor among the earnings equations for Hauptschule, Realschule and Gymnasium graduates to be the same. It permits free correlation among the error terms. Thus, it does not only account for selection, that is a truncation of the underlying error terms due to individual educational choices, but also for unobserved heterogeneity among the three secondary school groups.

Post-secondary education enters the earnings equation as an endogenous dummy. This similarly allows to account for self-selection. Under the assumption of homogenous returns to education and given the same set of explanatory variables in the earnings equations the endogenous dummy variable approach is equivalent to a switching regression model. But if unobserved heterogeneity among the different educational groups exists then the dummy endogenous model is not capable of separating unobserved heterogeneity from selection. This arises from the fact that the endogenous dummy model implicitly imposes that all coefficients except the constant are the same among individuals with the same secondary school degree but different post-secondary education choices. Including including interaction terms in the earnings equation relaxes this assumption. Furthermore, unobserved heterogeneity is unlikely to play a major role in the post-secondary education equation since I already allowed for differences in the unobservable components among the three secondary school groups.

Could I account for self-selection by using instrumental variable estimation techniques or two stage methods? In the presence of heterogeneity in returns to education, the necessary conditions for instrumental variable estimators to yield consistent estimates of the average return to education are very strict and are likely not to be satisfied by sources of exogenous variation in educational choices (see Card (1999) and Heckman (1997)). Heckman shows that instrumental variables techniques yield only consistent estimates of returns to education among the entire population, as well as among the individuals which received the respective educational degrees, if individuals decide to participate in education without taking into consideration unobservables that influence their returns. Furthermore, in the present model neither instrumental variable techniques nor two stage estimates can be applied as the dependent variable of the post-secondary education equation V is discrete (see Lee and Maddala (1976)).

4. Data and Descriptive Statistics

The data set used for the empirical analysis is taken from the German 95% Sample of the Socio-economic Panel (GSOEP). It consists of observations on full-time working German men in dependent employment who are younger than 59 and provide information on parental background. 1702 individuals altogether, 971 with Hauptschule degree, 346 with Realschule degree and 385 with a Gymnasium degree fulfill these requirements for the sample period 1984 to 1990. For each of these individuals one observation is used.[4]

Data restrictions arise from the fact that no information on the grades of the individual at the end of grade school or some other ability measure are at hand. When measuring returns to education, an omission of these variables leads to the so called ability bias in the OLS estimates. This arises as individuals with a higher ability are expected to earn more and to stay in school longer, so that the contribution of unobserved ability to productivity cannot be separated from that of education. However, as far as ability affects the degree of secondary school, post-secondary education choices and earnings, the free correlation among the error terms in my model may at least partially account for ability.

Several variables that affect the post-secondary education decision are not available in the GSOEP, such as for example the federal state where the individual went to school or parents' marital status and income. Given that higher income lowers the opportunity cost of funds to finance education, individuals with richer parents are more likely to attain post-secondary education. Fortunately, the GSOEP provides rather extensive information on parents' educational attainment and labor market status which allow to proxy family income. Information on the number of

[4] Including women would mean to account explicitly for the labor participation decision, which requires a different econometric model. For immigrants our educational choice model does not apply. 59 is chosen as the upper bound to account for the fact that most men retire before the full pension retirement age of 65.

In order to prevent the introduction of sample selection bias arising from different response behavior only one observation per individual is included. To avoid the inclusion of individual-specific outliers I use the representative observation of those individuals that participate more than twice in the panel. The representative observation is the observation of an individual with deflated earnings closest to his mean earnings where the mean is calculated over all the individual's observations available for the sample period which fulfill the selection criteria.

brothers and sister is available. However, I do not use it as non-responses are very high. Individuals with more brothers and sisters, are less likely to continue with post-secondary education as it is more costly for the family to give an additional year of education to each child.

Parents' educational and occupational background affects the decision of their children to pursue post-secondary education. This is a well-documented fact for the United States. For example, Lee et al. (1979) show that the probability to pursue post-secondary education increases with the years of parental education, as well as with family income. Card (1999) provides evidence on the fact that mother's education affects male completion of schooling in general to a weaker extend than father's education.

Table 2 presents the descriptive statistics of the data set used for the empirical analysis. As all family background variables are constructed as dummy variables, the mean of each variable multiplied by 100 equals the percentage of observations with the respective characteristic. It is easy to see that the percentage of individuals whose parents have a higher education increases with the level of secondary school. Similarly, the percentage of sons of blue-collar workers declines. The positive relation between parental education and post-secondary education remains unchanged. The picture gets less clear when analyzing this relation conditional on the secondary school degree. For example, the percentage of children with mothers or fathers with a Gymnasium degree is lower for men with vocational training than for men without vocational training among Realschule and Gymnasium graduates. Overall a positive relation between parental education and the vocational training choice can be observed. A closer look reveals that is only true for Hauptschule graduates. But as their number is much larger, their positive relation overlays the negative relation between the respective parental background variables and the decision to perform vocational training of Realschule and Gymnasium graduates.

I follow Abraham and Houseman (1993) and Winkelmann (1994) in using deflated monthly earnings as the dependent variable in the earnings equation. The use of monthly earnings is reasonable as measurement errors in hours are high.

Average monthly earnings increase with the level of secondary school. But do also wages conditional on post-secondary education increase with the secondary school degree? A first glance at individuals without post-secondary education does not provide a clear answer. Hauptschule graduates without vocational education earn 2907 DM, which is considerably higher than the respective earnings for Realschule (2133 DM) and Gymnasium graduates (2252 DM). However, this finding is not conclusive, as the level of experience of Hauptschule graduates in the sample is significantly higher than that of other graduates.

Monthly earnings of individuals with vocational education increase with the level of secondary school, although at the same time the average experience decreases. This suggests that when holding experience constant the difference in monthly earnings among secondary school graduates with a vocational training degree is even more pronounced.

Summarizing, the descriptive statistics reveal a positive relation between parental education and level of secondary school, as well as post-secondary education. Conditional on the secondary school type, the latter is not generally true. Mean monthly earnings increase with level of secondary education and post-secondary education.

5. Results

5.1 Secondary School and Post-secondary Education Choice

The positive relation between parental education and level of secondary school is reflected in the estimation results of the secondary school equation. Table 3 presents the estimates of two empirical models. The full model assumes that the level of secondary school determines endogenously the choice of post-secondary education. The constrained model imposes exogeneity of secondary school in the post-secondary education equation and constrains the correlation coefficients to be equal to zero.

The specification of the secondary school equation is determined by variables available in the GSOEP which affect the secondary school choice. As pointed out in section 4; several variables which are likely to influence the secondary school choice, such as ability, family income or the marital status of the parents are not at hand. As a consequence, the estimation has to rely on educational and occupational variables of the parents.

In both models, the coefficients of all variables have the expected positive sign and nearly all are significant. Table 3 reveals that sons of civil servants are very likely to go to a higher secondary school. The same holds for individuals whose father has a university degree. Similarly to other findings mentioned above, the results suggest that mother's education matters less (in the sense of having a lower coefficient) than father's education in determining educational behavior. The full model predicts that increasing the level of secondary education of the father from Hauptschule to Realschule reduces the probability to go to a Hauptschule by 0.2 and raises the probability to go to a Gymnasium by 0.16. Increasing mother's level of education similarly yields a reduction in the probability to go to Hauptschule by 0.06 and increases the probability to go to Gymnasium by 0.05. This confirms the impression derived from the section on descriptive statistics. The relation between parental background variables and level of secondary school is positive. Mother's education affects the probability to go to a higher secondary school to a lower degree than father's education.

Parents' education and labor market status play a less important role in the post-secondary education choice. This seems intuitive since the decision on post-secondary education is taken in the late-teens or early twenties (for male graduates from the Gymnasium). Variables, such as the education of the mother, which significantly influence the secondary school choice of men do not have any effect when it comes to deciding whether to perform some kind of post-secondary education. Consequently, the set of explanatory variables included in the post-secondary education equation is substantially reduced.

Table 4 presents the results of the post-secondary education equations with endogeneity (full model) and without endogeneity (constrained model) of schooling. As can be seen the correlation coefficient among secondary and post-secondary equation ρ_{sv} is negative for Hauptschule and Gymnasium graduates and positive for Realschule graduates. The estimates reflect this difference. While the coefficients on family background variables decrease in the full model relative to the constrained model for Hauptschule and Gymnasium graduates, they increase for Realschule graduates. The pronounced differences in the correlation coefficients as well as in the coefficients confirm the switching model approach.

The constrained model predicts that a Hauptschule graduate is most likely to perform vocational training if his father is civil servant or has a Realschule degree. Sons of civil servants and university graduates are most likely to go to university. The full model reveals a completely different picture. It predicts that the probability of an Hauptschule graduate to complete vocational training or of a Gymnasium graduate to acquire a university degree is highest for sons of blue-collar workers. These probabilities are also very high for children whose father has a Hauptschule degree.

The fact that $½_{sv}$ is significant, reveals that endogeneity matters. In Germany it is reasonable to expect that unobservables influencing secondary and post-secondary education choice are not orthogonal. This arises from the fact that in order to reach a specific occupation students usually have to complete secondary school and to pursue some post-secondary educational degree. Access to this in turn often requires a certain secondary school degree. Hence, individuals are likely to choose their highest secondary school degree and their post-secondary education simultaneously.

Interpretation of the signs of the correlation coefficient would be straightforward in a model which switches into a linear regression. A negative correlation coefficient means that if an individual with a low educational family background chooses to go to a higher secondary school, then his probability to continue with university would be underpredicted if selection is not accounted for. This underprediction arises from the fact that students who choose to go to a higher secondary school although their educational family background is weak, have a higher ability than the average population. Hence, their probability to go to university should be above average. Of course this only holds if - given that the educational background of the parents is positively correlated with family income - financing university education imposes no major constraints to children from low income families.

Similarly, think of a child from a highly educated family which chooses to go to a secondary school which is lower than what would have been the prediction based on his family background. If the child chooses to go to a lower secondary school than his family background suggests, that his ability (or taste for studying) may be lower than average and hence his probability to perform vocational training as well.

The expected probabilities of accomplishing vocational training or university conditional on the chosen type of secondary school, as well as the respective unconditional probabilities can be looked up in Table 5: The conditional probabilities of performing vocational training are calculated by using $\sum_{i=1}^{N_k} P_i(V_j = 1|k)$ where k and j are Hauptschule, Realschule or Gymnasium. The diagonal elements of the conditional probabilities provide evidence of the probability to perform vocational education (and to go to university for Gymnasium graduates) conditional on having chosen the respective secondary degree and hence they are calculated for j equal to k. The off-diagonal elements are the unobserved counter-factuals with j different from k.

In the constrained model the conditional probabilities reduce to $\sum_{i=1}^{N_k} P_i(V_j = 1)$. The difference between the two models is striking. While the probability to go to university decreases with the level of secondary school in the full model, it increase in the constrained model. Similarly, the probability to perform vocational training in Hauptschule decreases when conditioning on a higher level of secondary school in the full model but increases in the constrained one.

So, why do we observe these differences? The counter-factuals are the probability of an arbitrary student with a certain secondary school degree to perform post-secondary education if he would have gone to a different type of secondary school.

For example, 0.997 in the last column of Table 5 is the probability of an arbitrary Hauptschule student to go to university if he would have gone to a Gymnasium. Or put differently, 0.997 is the probability that someone, who in accordance with his family background would have been expected to go to Hauptschule and actual went to a Gymnasium obtains a university degree. Thus, the full model tells us that if a predicted Hauptschule student actually goes to a Gymnasium then his probability to go to university is substantially higher than that of a predicted Gymnasium graduate. Accounting for endogeneity thus reveals that the probability to go to university is above average for those who actually choose to go to a Gymnasium. Accordingly, the probability to participate in vocational training is below average for those who decide to go Hauptschule. This is consistent with the interpretation of the signs of ½$_{sv}$ in a conventional switching model as stated above.

Summarizing, there is a throughout positive correlation among the educational background variables of the parents and the secondary school choice. Family background plays a less important role in the post-secondary education decision. This relation differs among graduates from different secondary schools which confirms the existence of heterogeneity in the post-secondary education choice and hence the use of a switching model.

The correlation coefficient among secondary school and post-secondary education equation is significant for graduates from all three types of secondary school. Not accounting for endogenous selection, thus, yields biased estimates. As a consequence, the probability to perform vocational training for Hauptschule graduates who actually choose to go to Hauptschule would be overpredicted and the decision to go to university would be underpredicted for Gymnasium graduates. Accounting for endogeneity reveals that an individual whose father has no vocational degree is less likely to go to a Gymnasium than an individual whose father has a university degree. But if he went to a Gymnasium then his probability of attaining university is higher than the probability of the latter.

5.2 Returns to Education and Earnings Differentials

The basic specification of the earnings equation regresses the log of deflated average monthly earnings on educational dummies, experience and marital status: This simple form allows to compare my results with those of previous research. In what follows I will first present the OLS estimates, then analyze maximum likelihood estimates and finally discuss the earnings differentials.

Table 6 presents the results of various OLS regressions. In the left column of the table the estimates for the entire sample can be encountered. They suggest that a Realschule degree raises earnings by around 14% and a Gymnasium degree by 0.09%. German men without post-secondary education earn 22% less than their counterparts with a vocational education degree and 57% less compared to the holder of an academic degree. All values are significant, have the expected signs and are within the range of the values presented by Abraham and Houseman (1993) and Winkelmann (1994), who perform OLS cross-section estimations for Germany using the GSOEP.

As exposed in sections 2 and 5.1 graduates from different types of secondary school differ in the knowledge they receive during secondary school, the kind of post-secondary education they choose and their probability to continue with post-secondary education. This points at the existence of heterogeneity in the returns to post-secondary education. Separate regressions for each secondary school group reveal that imposing equal returns to vocational training among the three secondary school groups overestimates the returns to vocational training for Hauptschule and understates returns to vocational training for Realschule and Gymnasium graduates. Returns to university are underestimated. Vocational training raises monthly earnings of Hauptschule and Realschule graduates on average by 16 to 27%, ceteris paribus. Moreover, monthly earnings of Gymnasium increase on average 43%. Annual returns of vocational training thus amount to 5.2%, 9.1% and 21.3% for Hauptschule, Realschule and Gymnasium graduates. A university degree raises earnings by nearly 70% which corresponds to an annual return to university of about 14%. This is lower than annual returns to vocational training of Gymnasium graduates. Note however, that it is very likely that the true returns to vocational training are not as high as our estimates suggest due to the fact that participants of a vocational training program gain actual labor market experience during its completion, which is not necessarily the case for university graduates.[5]

[5] The completion of a vocational training program generally takes three years for Hauptschule and Realschule graduates and two years for graduates from a Gymnasium. To calculate annual returns to university (including technical colleges), I assume that it takes five years to accomplish a university degree.

Family background variables often have been used in order to control directly for unobserved ability or as instrumental variables for the level of education. Card (1999) shows that given that there are no measurement errors in family background variables, the upward bias in the OLS estimates will decrease as family background variables are included. (The bias of OLS with family background variables is even lower than the bias of the instrumental variable estimators). I find that the inclusion of family background variables in the earnings equation has no strong impact on the estimates of returns to education. The direction of the bias in the OLS estimates is ambiguous. This may arise from the fact that in Germany the post-secondary education choice conditional on the type of secondary school is not necessarily positively correlated with family background (see section 5:1).

For Germany it has been claimed that better educated individuals are more likely to work in industries which pay higher salaries. This hints at an upward bias of the OLS estimates when neither occupation nor industry controls are included in the specification. In accordance with previous findings (see, for example, Winkelmann (1994)), the inclusion of firm size dummies in the regression of the entire sample reduces returns to education slightly. The separate regressions for each secondary school type reveal a slightly different picture. Firm-size dummies are largely significant for Hauptschule graduates, but mostly insignificant for Realschule and Gymnasium graduates. The firm size dummies are not even jointly significant for these groups. The values of the 95 and 99 percentile of the $F(4; 1)$ are 2.37

and 3.34 respectively which compare to observed F-statistics of 1.2 for Realschule graduates and 2.8 for Gymnasium graduates. This finding may be explained by the fact that the percentage of graduates from Hauptschule is highest in such different vocational fields such as craft, domestic science or industry, while graduates from the Gymnasium usually choose areas such as civil service, banking and commerce.

Table 1 (below) presents a summary of the maximum likelihood estimates of the returns to post-secondary education.

Insert Table 1

The results of the full model clearly show that OLS estimates are biased. The direction of the bias however is ambiguous. OLS biases returns to vocational training upwards for Hauptschule graduates but downwards for Realschule and Gymnasium graduates. As a consequence the differences in returns to vocational training among graduates from different secondary schools increase substantially. Returns to a vocational training degree are more than five times higher for Gymnasium graduates than for Hauptschule graduates. Differences in annual returns are even larger. One year of vocational training increases earnings of Hauptschule, Realschule and Gymnasium graduates by 0.04%, 0.26% and 0.35% respectively.

The difference between the OLS and the full model university dummy is striking. It is the result of the two large negative correlation coefficients $½_{sv}$ and $½_{vw}$: The correlation coefficient among educational equations and earnings equation may become negative according to human capital theory if lower-wage individuals are more likely to invest in schooling than higher wage individuals, holding other things equal. Even if ability is not controlled for the negative correlation between education and earnings equation residuals may persist if, as Blackburn and Neumark (1995) point out, higher-ability individuals face higher costs in terms of foregone earnings costs at the margin.

The correlation coefficient between post-secondary education and earnings equation, ½$_{vw}$ is significant for Realschule and Gymnasium graduates. This finding may be the result of selection or due to measurement error in the educational attainment variables. The latter may lead to a correlation between the measured post-secondary education degree and the earnings equation. However, the fact that post-secondary education degrees and not years of education are used in this estimation suggests that measurement errors due to misreporting do not play an important role.

Post-secondary education enters the earnings equation in the form of an endogenous dummy. As explained in section 3 the endogenous dummy model implicitly imposes that all coefficients except the constant are the same among the types with different post-secondary education choices but the same secondary school degree. This assumption can be loosened by including interaction terms in the earnings equation. Besides the estimates of the basic specification, estimates with interaction terms are used to calculate earnings differential, as they allow for interesting insights.

Evidence on the predicted earnings differentials under random assignment is presented in Table 7. Given the assumption that an individual could be randomly assigned to two different secondary schools, these earnings differentials explain the respective percentage differences in earnings. They ignore selection. Earnings differentials based on OLS estimates are throughout positive, increase with years of experience and are largest between Gymnasium and Hauptschule. A married man with 15 years of experience and a vocational training degree earns, for example, 39% more if he obtained a Gymnasium instead of a Hauptschule degree. Differences in earnings for individuals without a vocational training degree are very low. The other three models (full model and models with interaction terms) reveal even negative earnings differentials. This may hint at the fact that individuals which have a higher secondary school degree, but do not continue with post-secondary education exhibit a bad signal.

Unconditional and conditional predicted earnings can be looked up in Table 8: Unconditional earnings refers to the mean earnings prior to the secondary school choice, that is $E(w_j)$ with j = Hauptschule, Realschule or Gymnasium. It is the average predicted value of the monthly earnings (for Hauptschule, Realschule and Gymnasium graduates) taken over all individuals in the sample. Unconditional earnings predictions are higher in the constrained models where selection is not accounted for. But what is more striking is the fact that both models with interaction terms predict unconditional earnings for Gymnasium graduates which are twice as high as the prediction of their respective counterparts without interaction terms. This may arise from the fact that heterogeneity still plays a role among Gymnasium graduates because Gymnasium graduates face the additional choice of going to university.

Conditional earnings refers to the mean earnings conditional on the secondary school choice. The diagonal elements in the first part of Table 8 provide information on $E(w_j|S = k)$ for $k = j$. Again j refers to Hauptschule, Realschule or Gymnasium. For example, 3238.13 DM are the average earnings of Hauptschule graduates who actually choose to go to Hauptschule. These elements are rather similar among the models. The major difference lies in the fact that the models with interaction terms predict significantly higher conditional earnings for Gymnasium graduates. Comparing conditional earnings with unconditional earnings, it can be seen, that conditional earnings are always higher for Hauptschule graduates and lower for Realschule graduates. As for Gymnasium graduates this again depends on the type of model: unconditional earnings are higher in the models with interaction terms but lower in the models without them.

The off-diagonal elements in this part of the Table shed light on $E(w_j|S = k)$ for $k \neq j$, the so called counter-factuals. For example, 3025.73 DM corresponds to $E(w_R|S = H)$ which is the expected potential earnings of a Hauptschule graduate would he have chosen to go to Realschule. Conditional on a certain type of secondary school earnings increase from the left to the right. This means that a certain secondary school graduate would have earned less if he would have chosen a lower type of secondary school degree, but more if he would have chosen a higher type secondary school degree. Moreover, all models suggest that the expected earnings of a Hauptschule graduate who actually choose to go to a Gymnasium is higher than the conditional earnings of a Gymnasium graduate.

The percentage differences among counter-factuals and the respective conditional earnings are much more pronounced when selection is taken into consideration. The two full models state that conditional earnings of a Hauptschule student is about 27% higher than the earnings of a predicted Gymnasium graduate who chooses to go to Hauptschule. The same earnings differential amounts to only 20% in the constrained models. Similarly, the difference in earnings between a Gymnasium and a predicted Hauptschule graduate with a Gymnasium degree is only 6% in the constrained model, but 50% (16%) in the full model (with interaction terms). These results are in line with the findings in section 5:1 that the probability to go to university is above average for Hauptschule graduates who actually choose to go to a Gymnasium and below average for the Gymnasium graduates who decide to go Hauptschule once endogeneity is accounted for.

Earnings differentials in percentage terms between observed sample earnings and counter-factuals, as well as between conditional earnings and counter-factuals can be found in Table 9: Earnings differentials are often called the gross benefit of participating in a program which refers in our case to completing a certain type of secondary school. It is usually used to evaluate the success of a program. These earnings differentials are nearly throughout positive for Gymnasium graduates. For Hauptschule graduates the contrary is the case. According to nearly all models, they would have been better off on average by choosing another type of school. And what is more, even expected earnings differentials reveal the same signs. This may be an explanation for increasing (decreasing) enrollments rates in Gymnasium (Hauptschule). Furthermore, it can be observed that not accounting for endogeneity underpredicts the earnings gains of going to a Gymnasium for those who obtained and the losses of those who did not obtain a Gymnasium degree.

Do the negative earnings differentials for Hauptschule and Realschule graduates indicate that they are not rational? The negative earnings differential may be the result of the peculiarity of the German education system, that individuals are selected into the three different types of secondary schools at the age of ten. Mobility among these schools increased largely during the 80's, but was not very common before. It hence does not apply to most of the individuals in my sample. The rigidity of the system may have resulted in misallocations and prevented the agents of making optimal decisions. Moreover, unemployment rates affect the three secondary school groups differently. During the 80's unemployment rates of Hauptschule students increased twice as much as those of students from the Realschule or Gymnasium. And individuals without vocational qualification faced the highest growth in unemployment compared to those with post-secondary education degrees. Unemployment rates among university graduates increased. Expected earnings differentials thus may reveal a different picture if unemployment is accounted for.

The estimation results presented above clearly show that OLS estimates are biased. The direction of the bias however is ambiguous. OLS biases returns to vocational training upwards for Hauptschule graduates but downwards for Realschule and Gymnasium graduates. One year of vocational training increases monthly earnings of Hauptschule, Realschule and Gymnasium graduates by 4%, 26% and 35%, respectively. Accounting for endogeneity and selection, reveals that annual returns to vocational training are eight times higher for Gymnasium graduates than for Hauptschule graduates and that returns to vocational training differ to a much larger extend among the three types of secondary school than OLS estimates suggest.

6. Conclusion

In the previous sections I present a simultaneous equation model with endogenous dummy variables and switching, which captures the basic features of the German education system. Using this model I estimate average returns to post-secondary education in Germany and calculate earnings differentials among graduates from three different types of secondary school. Moreover, I analyze differences in post-secondary choice behavior, address the question whether selection into post-secondary education matters and whether post-secondary education should be treated endogenously.

I find that the relation between parents' education level and the probability to go to a higher secondary school is throughout positive. The relation between parents education and post-secondary education choices is much weaker and not unambiguous. The correlation coefficient between secondary school and post-secondary education equation is significantly different from zero for all three groups. As a consequence, not accounting for selection, underpredicts the probability to go to university for a Gymnasium graduate and overpredicts the probability of a Hauptschule student to perform vocational training.

The results reveal that the three secondary school groups differ not only in their post-secondary education choices, but also in their returns to vocational training. When selection into the type of secondary school is considered and endogeneity of post-secondary education in the earnings equation is allowed for, annual returns to vocational training are more than eight times higher for Gymnasium graduates than for Hauptschule graduates. Annual returns to vocational training increase with the level of secondary school.

Endogeneity of secondary school and post-secondary education matter. This implies that OLS estimates are biased. However, the bias is not unidirectional. Concerning annual returns to vocational training, OLS overstates returns for Hauptschule graduates by more than 20 % but understates returns for Gymnasium graduates by 60 %. Returns to university are more than twice as high as OLS suggests.

The model presented in this study can be extended in three directions: The first one is to account for the high complexity of the Germany education system and to expand the set of post-secondary education choices. The second points towards including additional endogenous variables such as experience and hours. Third, unemployment should be considered. It affects the three secondary school groups to a different extent. During the 80's unemployment rates of Hauptschule students increased twice as much as those of students from the Realschule or Gymnasium. And individuals without vocational qualification faced the highest growth in unemployed compared to those with post-secondary education degrees. This suggests that the characteristics of those in work and out of work differ. Controlling for this potential ”composition bias” may provide fruitful insights in the ”real” differences of returns to education in Germany.

References

Abraham, K. and Houseman, S., 1993. Earnings inequality in Germany. Working paper 4541, NBER, Cambridge, MA.

Blackburn, M. and Neumark, D., 1995. Are OLS estimates of the return to schooling biased downward? Another look. The Review of Economics and Statistics, 77 (2) , 217-330.

Card, D., 1999. The causal effect of education on earnings. In: Ashenfelter, O.,Card, D. (Eds.) Handbook of labor economics, vol. 3, 1801-1863.

Heckman, J., 1997. Instrumental variables. Journal of Human Resources 32 (3), 441-462.

Ichina, A. and Winter-Ebmer, R., 1999. Lower and upper bound of returns to schooling: An exercise in IV estimation with different instruments. European Economic Review 43, 889-901.

Lee, L. and Maddala, G., 1976. Recursive models with qualitative endogenous variables. Annals of Economic and Social Measurement 5 (4), 525-545.

Lee, L. et al., 1979. Returns to college education: An investigation of self-selection bias based on the project talent data. International Economic Review 20, 775-789.

Knoll, L. and Störk, U., 1993. Altersverdienstprofile westdeutscher Arbeitnehmer 1984-1991. DIW Vierteljahresheft, 172-196.

Winkelmann, R., 1994. Training, earnings and mobility in Germany. Discussion paper no. 982, CEPR, London.

Tables

Table 1 Returns to Education: Summary

	Full Model	½$_{sw}$ = 0	½$_{vw}$ = 0	½$_{sw}$ = ½$_{sv}$ = 0	½$_{vw}$ = ½$_{sv}$ = 0	OLS
HAUPTSCHULE						
Vocational Training	0.130	0.140	0.156	0.130	0.157**	0.157**
½$_{sw}$	-0.001	-	0.005	-	-0.032	-
½$_{vw}$	0.034	0.026	-	0.050	-	-
½$_{sv}$	-0.864**	-0.864**	-0.708**	-	-	-
REALSCHULE						
Vocational Training	0.771**	0.769**	0.269**	0.752**	0.274**	0.273**
½$_{sw}$	-0.066	-	-0.033	-	-0.034	-
½$_{vw}$	-0.527*	-0.611*	-	-0.696**	-	-
½$_{sv}$	0.763**	0.742	0.264	-	-	-
GYMNASIUM						
Vocational Training	0.697**	0.389**	0.431**	0.378**	0.425**	0.425**
University	1.445**	0.587	0.685**	0.563**	0.672**	0.670**
½$_{sw}$	0.001	-	0.058	-	0.054*	-
½$_{vw}$	-0.506**	0.081	-	0.107	-	-
½$_{sv}$	-0.842**	-0.843	0.309	-	-	-
Log Likelihood	-1.6314	-1.6315	-1.6335	-1.6330	-1.6343	-1.6344

Full Model imposes no constraints on ½$_{sv}$, ½$_{sw}$ and ½$_{vw}$. ½$_{sv}$, ½$_{sw}$ and ½$_{vw}$ are the correlation coefficients between secondary school/post-secondary education equation, secondary education/earnings equation and post- secondary education/earnings equation, respectively. Number of observations: 1702 for all models. **Significant at 0.10 level. *Significant at 0.05 level.

Table 2 Descriptive Statistics

	Total	Haupt-schule	No Voc	Voc	Real-schule	No Voc	Voc
# observations	1702	971	135	836	346	25	321
Earnings	3741.13	3386.94	2907.18	3464.41	3642.32	2133.01	3759.87
Experience	1.888	2.193	2.325	2.171	1.536	0.792	1.594
Married	0.634	0.670	0.615	0.679	0.546	0.120	0.579
Mother Realschule	0.101	0.039	0.037	0.039	0.116	0.000	0.125
Mother Gymnasium	0.024	0.004	0.000	0.005	0.014	0.040	0.012
Mother Post-sec. Education	0.444	0.341	0.230	0.359	0.566	0.760	0.551
Father Realschule	0.108	0.051	0.022	0.056	0.156	0.160	0.156
Father Gymnasium	0.079	0.016	0.007	0.018	0.061	0.080	0.059
Father Vocational Training	0.766	0.780	0.689	0.794	0.798	0.840	0.794
Father University	0.073	0.009	0.007	0.010	0.064	0.080	0.062
Father Independent Worker	0.161	0.154	0.170	0.152	0.162	0.160	0.162
Father White-collar Worker	0.175	0.100	0.067	0.105	0.240	0.240	0.240
Father Civil Servant	0.129	0.072	0.037	0.078	0.118	0.200	0.112

Earnings = monthly earnings. Experience = (age - years of education - 6)/10. All other variable are dummies.

Table 2 Descriptive Statistics continued

	Gym– nasium	No Voc	Voc	Uni
# observations	385	37	103	245
Earnings	4723.20	2252.45	3875.57	5452.69
Experience	1.438	0.746	1.435	1.543
Married	0.621	0.216	0.544	0.714
Mother Realschule	0.244	0.270	0.243	0.241
Mother Gymnasium	0.083	0.108	0.049	0.094
Mother Post-sec. Education	0.592	0.568	0.641	0.576
Father Realschule	0.205	0.189	0.165	0.224
Father Gymnasium	0.255	0.297	0.252	0.249
Father Vocational Training	0.701	0.676	0.680	0.714
Father University	0.242	0.216	0.233	0.249
Father Independent Worker	0.177	0.189	0.146	0.188
FathervWhite-collar Worker	0.304	0.351	0.330	0.286
Father Civil Servant	0.283	0.216	0.214	0.322

Variable description as above.

Table 3 Secondary School Equation: Estimation Results

	Full Model		Constrained Model	
Constant	-0.838**	(0.085)	-0.848**	(0.084)
Mother Realschule	0.161**	(0.093)	0.397**	(0.115)
Mother Gymnasium	0.575**	(0.227)	0.639**	(0.238)
Mother Post-secondary Education	0.207**	(0.060)	0.232**	(0.067)
Father Realschule	0.509**	(0.107)	0.442**	(0.110)
Father Gymnasium	0.684**	(0.195)	0.574**	(0.217)
Father Vocational Training	0.188**	(0.093)	0.178**	(0.092)
Father University	0.823**	(0.227)	0.814**	(0.245)
Father Independent Worker	0.310**	(0.090)	0.308**	(0.090)
Father White Collar	0.606**	(0.090)	0.581**	(0.090)
Father Civil Servant	0.651**	(0.102)	0.664**	(0.101)
Threshold School c_s	0.702**	(0.034)	0.707**	(0.034)
Log Likelihood	-1.6314		-1.6344	

Full Model imposes no constraints on $½_{sv}$, $½_{sw}$ and $½_{vw}$. Constrained Model imposes that $½_{sv} = ½_{sw} = ½_{vw} = 0$. $½_{sv}$, $½_{sw}$ and $½_{vw}$ are the correlation coefficients between secondary school and post-secondary education equation, secondary school and earnings equation and post- secondary education and earnings equation, respectively. Figures in parentheses are standard errors. Number of observations: 1702.
** Significant at the 5 % level.

Table 4 Post-secondary Education Equation: Estimation Results

	Full Model		Constrained Model	
HAUPTSCHULE				
Constant	0.405**	(0.127)	0.833**	(0.106)
Father Realschule	-0.160	(0.275)	0.384	(0.303)
Father Gymnasium	-0.180	(1.042)	0.526	(1.256)
Father Vocational Training	0.038	(0.131)	0.263**	(0.120)
Father University	-0.954	(0.979)	-0.299	(1.198)
Father Independent Worker	-0.188	(0.121)	-0.005	(0.140)
Father White Collar Worker	-0.289	(0.202)	0.185	(0.195)
Father Civil Servant	-0.212	(0.255)	0.336	(0.266)
½$_{sv}$	-0.864**	(0.156)	-	-
REALSCHULE				
Constant	0.311	(0.931)	1.760**	(0.357)
Father Realschule	0.434	(0.355)	0.128	(0.535)
Father Gymnasium	0.554	(0.708)	-0.005	(1.661)
Father Vocational Training	0.025	(0.362)	-0.256	(0.362)
Father University	0.188	(0.951)	-0.268	(1.701)
Father Independent Worker	0.173	(0.228)	-0.092	(0.323)
Father White Collar Worker	0.572**	(0.268)	-0.084	(0.281)
Father Civil Servant	0.299	(0.452)	-0.388	(0.499)
½$_{sv}$	0.763**	(0.279)	-	-
GYMNASIUM				
Constant	2.348**	(0.151)	0.729**	(0.273)
Father Realschule	-0.216*	(0.131)	0.036	(0.183)
Father Gymnasium	-0.423**	(0.173)	-0.358	(0.229)
Father Vocational Training	0.032	(0.132)	0.506*	(0.270)
Father University	-0.202	(0.238)	0.717**	(0.351)
Father Independent Worker	-0.296**	(0.131)	0.232	(0.206)
Father White Collar	-0.495**	(0.116)	0.033	(0.194)
Father Civil Servant	-0.391**	(0.137)	0.400**	(0.201)
Threshold university c_G	0.738**	(0.077)	0.978**	(0.089)
½$_{sv}$	-0.842**	(0.063)	-	-
Log Likelihood	-1.6314		-1.6344	
#observations	1702		1702	

** Significant at the 5 % level. * Significant at the 10 % level. See also Table 3.

Table 5 Probabilities to Pursue Post-secondary Education

	Hauptschule Vocational Training	Realschule Vocational Training	Gymnasium Vocational Training	Gymnasium University
conditional on				
Full Model				
Hauptschule	0.861	0.529	0.003	0.997
Realschule	0.391	0.922	0.049	0.949
Gymnasium	0.090	0.986	0.268	0.634
Constrained Model				
Hauptschule	0.861	0.933	0.293	0.583
Realschule	0.877	0.928	0.282	0.606
Gymnasium	0.896	0.914	0.267	0.637
unconditional				
Full Model	0.590	0.712	0.072	0.905
Constrained Model	0.872	0.928	0.285	0.600

0.529 e.g. is $\sum_H P_i(V_{Realschule} = 1 | H)/N_H$: H refers to Hauptschule.
N_H is the number_of Hauptschule graduates.

Table 6 Earnings Equations: OLS

	All		Hauptschule		Realschule		Gymnasium	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Constant	7.152	0.036	7.429	0.042	7.145	0.073	6.833	0.087
Realschule	0.139	0.023						
Gymnasium	0.091	0.033						
Vocational Training	0.217	0.028	0.157	0.029	0.273	0.069	0.426	0.085
University	0.570	0.043					0.670	0.081
Experience	0.612	0.035	0.377	0.042	0.754	0.072	0.969	0.098
Experience^2	-0.113	0.008	-0.066	0.009	-0.139	0.017	-0.201	0.025
Married	0.134	0.023	0.136	0.028	0.077*	0.045	0.208	0.057
R^2	0.434		0.267		0.513		0.554	

Specification with family background variables includes all family background variables.

* Not significant at 0.05 level. ** Not significant at 0.10 level. Dependent variable: log monthly earnings.

Table 7 Predicted earnings differential in % under random assignment

	Full Model	Full Model Interaction	OLS	OLS Interaction
Vocational Training, experience 15, married				
Realschule/Hauptschule	24.39	24.27	19.04	18.38
Gymnasium/Hauptschule	2.94	35.56	38.99	43.87
Gymnasium/Realschule	-17.24	9.17	16.77	21.53
Vocational Training, experience 15, not married				
Realschule/Hauptschule	34.18	32.91	26.27	24.70
Gymnasium/Hauptschule	-5.26	28.18	29.34	35.63
Gymnasium/Realschule	-29.34	-3.56	2.43	8.76
No Vocational Training, experience 15, married				
Realschule/Hauptschule	-34.48	-15.04	6.00	40.11
Gymnasium/Hauptschule	-41.61	-12.91	6.21	-4.09
Gymnasium/Realschule	-10.99	2.51	0.20	-31.55
Vocational Training, experience 10, married				
Realschule/Hauptschule	12.30	13.09	8.00	8.00
Gymnasium/Hauptschule	-8.24	14.80	22.38	20.92
Gymnasium/Realschule	-18.29	1.51	13.31	11.96
Vocational Training, experience 20, married				
Realschule/Hauptschule	32.71	31.92	26.19	25.61
Gymnasium/Hauptschule	8.44	47.99	47.65	58.88
Gymnasium/Realschule	-18.29	12.99	16.66	26.49

Interaction refers to an extension of the basic specification by means of an inclusion of interaction terms of post- secondary education dummies and experience, as well as experience squared.

Table 8 Predicted earnings

	Conditional earnings Hauptschule	Realschule	Gymnasium	Unconditional earnings
Full Model				
Hauptschule	3238.13	3015.73	6360.42	3092.81
Realschule	2807.23	3387.45	5550.53	3445.45
Gymnasium	2522.86	3426.38	4219.66	3241.39
Full Model with Interaction Terms				
Hauptschule	3236.96	3709.33	5852.12	3082.21
Realschule	2843.25	3419.77	4230.62	3552.82
Gymnasium	2555.23	4884.85	5035.79	6641.38
Constrained Model				
Hauptschule	3236.88	3901.65	4475.74	3086.05
Realschule	2993.03	3462.24	4081.22	3565.82
Gymnasium	2689.84	3470.43	4248.33	3959.81
Constrained Model with Interaction Terms				
Hauptschule	3230.47	3973.27	5271.38	3076.11
Realschule	2990.11	3517.76	4386.60	3759.23
Gymnasium	2687.21	4949.87	4935.27	7329.85

Conditional earnings is $E(w_j|S = k)$ with j corresponding to the horizontal reference and k to the vertical references. Unconditional earnings is $E(w_j)$ taken over all individuals in the sample. j and k take the values Hauptschule, Realschule or Gymnasium.

Table 9 Earnings differentials and expected earnings differentials in %

	Full Model	Full Model with Interaction Terms	Constrained Model	Constrained Model with Interaction Term
Earnings Differentials				
w_H - $E(w_R|H)$	10.96	-9.52	-15.20	-17.31
w_H - $E(w_G|H)$	-87.79	-72.78	-32.15	-55.64
w_R - $E(w_H|R)$	22.93	21.94	17.83	17.91
w_R - $E(w_G|R)$	-52.39	-16.15	-12.05	-20.43
w_G - $E(w_H|G)$	42.47	42.32	35.69	36.36
w_G - $E(w_R|G)$	27.46	-3.42	26.52	-4.80
Expected Earnings Differentials				
$E(w_H|H)$ - $E(w_R|H)$	6.87	-14.59	-20.54	-22.99
$E(w_H|H)$ - $E(w_G|H)$	-96.42	-80.79	-38.27	-63.18
$E(w_R|R)$ - $E(w_H|R)$	17.13	16.86	13.55	15.00
$E(w_R|R)$ - $E(w_G|R)$	-63.86	-23.71	-17.88	-24.70
$Ew_G|G)$ - $E(w_H|G)$	35.61	45.90	28.80	39.10
$E(w_R|R)$ - $E(w_R|G)$	18.80	3.00	18.31	-0.30

w referes to actual earnings received. Subindices refer H,R and G to Hauptschule, Realschule and Gymnasium.

Figures

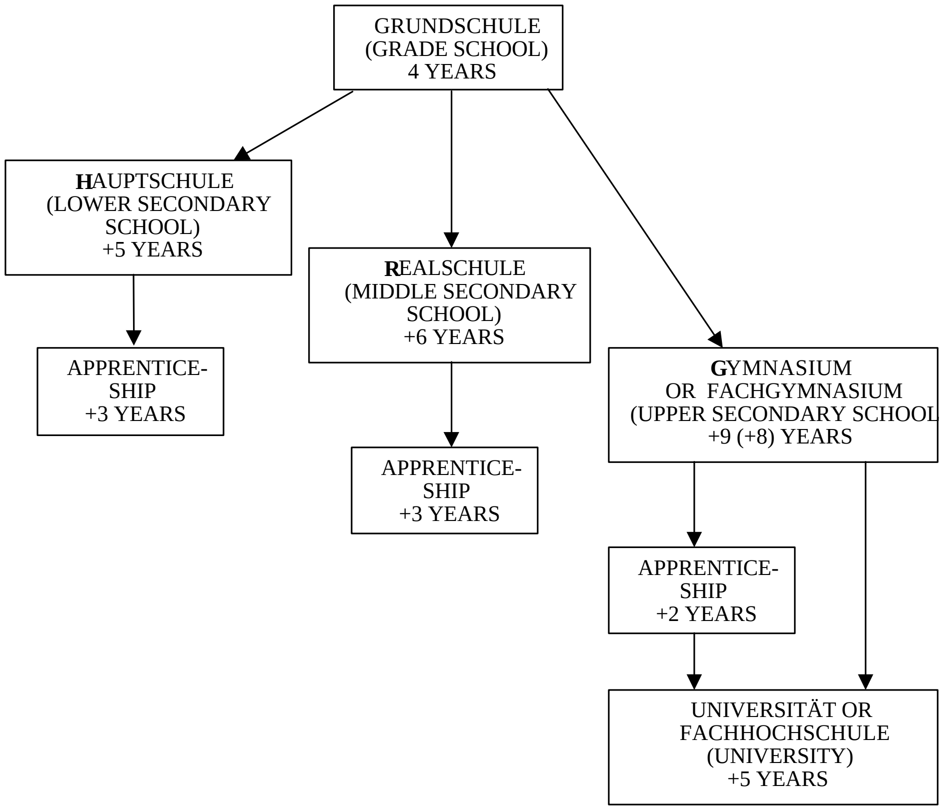

Figure 1: German Education System

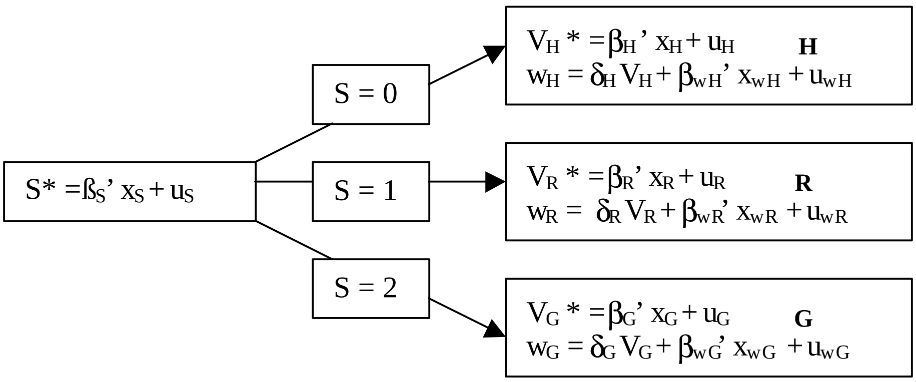

Figure 2: Empirical Model

Appendix

A1 German Post-secondary Education System

Figure 1 abstracts from the fact that special schools exist which offer graduates from Hauptschule or Realschule the opportunity to accomplish the respective subsequent secondary school degree. Only few individuals in my sample take these options. Vocational training can be accomplished through different types of training but its heart is the apprenticeship. In order to perform an apprenticeship students apply to firms or master craftsmen. They receive earnings which increase with each year of the apprenticeship but remain considerably below post-apprenticeship earnings. Completion of an apprenticeship takes two or three years depending on the secondary school degree.

Specialized vocational schools provide a further range of post-secondary vocational training choices. There exist part-time and full-time vocational schools on a lower level, which allow to receive a general preparation for an occupation (Berufsschulen or vocational schools), as well as specialized vocational schools (Fachschulen or Trade and Technical schools), health schools or schools for public administration on a higher level. Latter are attended usually after several years of work experience. All programs last between one and two years.

Academic education can be pursued in universities or technical colleges (Fachhochschulen). Technical colleges provide an applied professional formation for professions which require the application of scientific knowledge and methods.

Studies are offered in fields such as engineering, economics, social studies, agriculture and design.

A2 GSOEP

The German 95% Sample of the Socio-economic Panel (GSOEP) is a longitudinal survey of private households and persons. Initiated in 1984 in the Federal Republic of Germany (FRG), it was expanded to the territory of the German Democratic Republic in June 1990. The sample population consists of the population that lives and receives their income in Germany independent of their nationality. 12245 persons above 16 years in 5921 households were included in the first wave (annual survey). This number decreased to 8467 persons (ca.70%) in 4389 households in 1997 for the West-SOEP.

The participation in the SOEP is voluntary. Consequently, in contrast to social security records the sample is not capped and information about incomes above the respective annual social security earnings cap is available. Furthermore, records of individuals are not linked with records of spouses. Disadvantages of voluntary participation are that the number of non-responses or implausible values is high and that monthly earnings are often rounded off to 100 or 1000 DM. Additionally, voluntary participation leads to a bias in favor of the middle class.

A3 Annual Individual Labor Earnings

As the German tax and transfer system makes it extremely difficult to control for all the factors that determine the post-government income at the individual level, post-tax labor earnings are used here. According to the GSOEP methodology labor earnings include earnings and salary from all employment including training, primary and secondary jobs, and self-employment, plus income from bonuses such as 13th month pay, 14th month pay, Christmas bonus pay, holiday bonus pay, miscellaneous bonus pay, overtime, and profit-sharing. Monthly earnings then are calculated by dividing annual earnings by twelve.