

Human Capital vs. Signaling

The German Reunification as a Natural Experiment^{*}

Ulf Rinne[†]

IZA

Zhong Zhao[‡]

Renmin University of China, IZA

Preliminary Draft

May 5, 2010

Abstract

This paper revisits the debate between Becker's theory of human capital and Spence's signaling approach towards education. We explicitly test the theoretical predictions of these two opposing approaches using the German reunification as a natural experiment. More specifically, we exploit the variation in the influence of the political system on curricula across fields of study in university education. We calculate the extent to which different fields of study were influenced by the socialist regime, and apply a difference-in-differences approach for East and West German university graduates. According to the theory of human capital, the value of university degrees obtained in the GDR which were highly influenced by the regime (e.g., law, economics, history) was substantially depreciated when Germany was reunified in 1990. This would not be the case under the signaling assumption. Our results can be viewed as evidence in favor of the human capital theory: we find that the returns to such degrees have been significantly lower than those to degrees in fields of study which had been moderately influenced (e.g., medical sciences).

Keywords: Human Capital; Signaling; Transition Economy; University Education; East Germany; Reunification

JEL Classification: I21, J24, J31, P39

^{*}We would like to thank Daniel S. Hamermesh, David A. Jaeger, Solomon W. Polachek and participants in the IZA Internal Seminar for helpful discussions and comments on earlier drafts of this paper. We are very grateful to Daniela Geppert for excellent research assistance. The usual disclaimer applies.

[†]Ulf Rinne, IZA, P.O. Box 7240, 53072 Bonn, Germany. Email: rinne@iza.org

[‡]Zhong Zhao, School of Labor and Human Resources, Renmin University of China, 59 Zhong-guancun Ave, Beijing, 100872, China. Email: mr.zhong.zhao@googlemail.com

1 Introduction

This paper revisits the debate between the theory of human capital and the signaling approach towards education. While the theory of human capital assumes that investments into education directly increase a worker's productivity (Becker, 1962, 1993), the signaling approach assumes that education only serves as a signal for otherwise unobservable abilities, importantly without increasing a worker's productivity (Spence, 1973, 1974).

What is the relative importance of these two approaches? It has proven difficult to find a satisfactory answer to this old question, mainly because the behavior of economic agents is rather similar in both models: *a*) individuals chose schooling to maximize lifetime resources, and *b*) firms hire workers as long as wages equal productivity. Both models aim at explaining the observed positive relation between schooling and wages. But whereas in the theory of human capital this is assumed to reflect a causal relationship, the signaling approach views a person's productive capacity as a sort of intrinsic quality, which is reflected by schooling choices to signal this unobserved ability. The two models thus arrive at different conclusions concerning the efficiency of investments in education: individual choices are socially efficient under perfect competition according to the theory of human capital, but workers have a tendency to overeducate themselves under the signalling assumption. A satisfactory answer to which extent one or the other model applies is thus desirable.

The German reunification offers us a unique opportunity to explicitly test theoretical predictions of these two opposing approaches. More specifically, we exploit the variation in the influence of the political system on curricula across fields of study in university education in the German Democratic Republic (GDR). Although all students were required to take Marxism-Leninism courses, the percentages of these courses differed across fields, ranging from 20 to 30 percent. In addition to the obligatory courses in Marxism-Leninism, the socialist ideology influenced the content of other elective courses. Again, the degree of influence is different across fields: for instance, while there was virtually no influence in medical sciences, in economics more than 20 percent of the courses were influenced by the regime. But this variation may have important implications after German reunification, which importantly vary by the underlying model. In the human capital

model, the value of some university degrees obtained in the GDR stayed relatively constant as the curricula had been more or less the same in both German countries (e.g., medical sciences, natural sciences, technical sciences), whereas the value of other university degrees obtained in the GDR was substantially depreciated as the curricula were highly influenced by the socialist regime (e.g., law, economics, history). But under the alternative assumption, namely that education merely serves as a signal for otherwise unobservable abilities, the value of university degrees obtained in the GDR should stay relatively constant across fields of study (or depreciated to a similar extent)—irrespective of whether or not and to which extent the political system had influenced the respective curriculum.

Our results can be seen as evidence in favor of the theory of human capital. We find that the value of university degrees obtained in the GDR which were highly influenced by the socialist regime was substantially depreciated after reunification. Degrees in fields of study which were influenced to a smaller extent also depreciated, but to a significantly smaller extent. Furthermore, our results indicate that the differences in depreciation rates across fields of study seem to fade out over time. This may reflect that work experience in the market economy becomes more important over time.

Importantly, we also find that the evidence in favor of Becker's human capital theory only appears when we measure the extent to which fields of subjects have been influenced by the regime focusing on courses *in addition* to the compulsory studies of Marxism-Leninism. But this is what one may have suspected from the very beginning: the studies of Marxism-Leninism were not only obligatory, but also identical for every student—importantly, across different fields of study. Therefore, the variance in the influence of the socialist regime through other (i.e., additional) courses appears much more important than the variance through Marxism-Leninism itself.

The remainder of the paper is organized as follows: Section 2 discusses the existing empirical evidence. Section 3 describes the institutional background, i.e., the German reunification and the systems of higher education in both parts of Germany. We then present the methods in Section 4, our data in Section 5, and our main results in Section 6. Finally, Section 7 concludes, provides a summary of our findings and discusses potential threads to our identification strategy.

2 Related Empirical Literature

There are a number of empirical studies which test the validity of the theoretical predictions of the two opposing approaches towards education. We identify five different strategies that attempt to determining the importance of signaling.

The first line of research includes studies which either consider variables which are assumed to measure both academic and nonacademic attributes, or consider both absolute and relative measures of education, or look at whether degrees matter or not ('sheepskin effects'). Examples for the these approaches find that education is not only a signal but also productivity enhancing (Wise, 1975), and that the theory of human capital is the predominant explanation of schooling's value (Kroch and Sjoblom, 1994). Similarly, Kane and Rouse (1995) estimate only small sheepskin effects of degree receipt over and above the value of the credits completed when analyzing the labor market payoffs of community college education. In general, they find similar returns to two-year and four-year college credits. However, the study of Jaeger and Page (1996) finds that using the information on degree receipt substantially increases the estimated sheepskin effects. Their results imply that the signaling component of educational attainment varies with the type of education, and that sheepskin effects matter in the returns to education.

Second, there are a number of studies determining the importance of signaling by distinguishing between occupations or occupational groups for which screening may be more or less important. For instance, Taubman and Wales (1973) compare the the actual occupational distribution of individuals at various education levels with the expected distribution under free entry, assuming that each individual would select the category in which his or her earnings are the highest. By comparing the expected and actual distributions across occupations, the authors conclude that education is used as a screening device. Those individuals with low educational attainment seem to be prevented from entering high-paying occupations. Wolpin (1977) compares screened and unscreened individuals. Based on the comparison between self-employed and salaried workers which should approximate a comparison between screened and unscreened individuals, his results suggest that schooling has only a minor screening function. The self-employed acquire roughly 75 percent of the amount of extra schooling

acquired by the salaried workers, but are of similar pre-school productivity. However, with respect to earnings screening seems to be of greater relevance. Riley (1979) focuses on different occupations rather than on two broadly defined occupational groups. He argues that screening would be more important in some occupations than in others; and he indeed finds evidence supporting this hypothesis. The observed differences across occupations, it is concluded, are consistent with the screening or signaling approach towards education. His empirical results are consistent with implications derived from a theoretical model with screened and unscreened occupations.

The third attempt analysis employers' hiring behavior. It follows the idea that signaling is especially relevant in the hiring process: employers have to rely for example on schooling to predict productivity. Subsequently, the employers' observe workers' performance and thus learn about their unobserved ability, and the signaling contribution declines. This approach has been introduced by Albrecht (1981) and more recently pursued and further developed in Albrecht and van Ours (2006). The latter contribution empirically tests the signaling hypothesis using data about the hiring behavior of Dutch employers across different recruitment channels. The argument is that if education is used as a signal in the hiring process, employers will rely more on this information when less is otherwise known about an applicant. Results indeed show that employers are more likely to deviate from *ex ante* stated educational requirements when there is information available from other sources. Therefore, the hypothesis that education is *not* used as a signal in the hiring process is rejected. Lange (2007) presents further evidence on the speed with which learning about the workers' productivity takes place. He finds that employers learn quickly: initial expectation errors decline by 50 percent within three years. This estimate furthermore places an upper bound on the contribution of signaling to the gains from schooling, which is less than 25 percent in most cases.

The fourth line of research makes creative use of a natural experiment. Lang and Kropp (1986) exploit the variation in compulsory school attendance laws across the United States. While according to the theory of human capital such laws only affect individuals who are directly constrained, under the signaling hypothesis also high-ability workers are affected who attend school for a longer period in any case. Given that a specific year of schooling used to be a signal but

this year of schooling is compulsory for everybody under a new legislation, high ability individuals now have to get additional schooling to distinguish themselves. The authors find evidence supporting the signaling hypothesis as enrollment rates also increase in age groups which are not directly affected by the law.

Finally, Tyler et al. (2000) follow a similarly and maybe even more creative strategy that also exploits a natural experiment. They observe that passing grades in the General Educational Development (GED) tests differ across the United States. This means that an individual with a given score in this test will get the GED in one state, but not in another. Under the theory of human capital and under the assumption that the GED is an unbiased measure of human capital, individuals with a similar test score should also get similar wages—irrespective of whether the GED is awarded or not. However, if the GED is a signal and employers are not aware of different passing standards or do not know where the GED exam was taken, wages should differ. The authors estimate such earnings differences on the margin of passing the GED exams and thus support the notion that GED serves as a signal.

Altogether, most of the empirical evidence suggests that *in addition* to increasing a worker's productivity, education serves *to some degree* as a signal of greater productivity, and this signal translates into higher earnings in the labor market. Both the theory of human capital and the signaling approach towards education are therefore tenable on empirical grounds. This paper adds to the existing literature and makes use of a clear natural experiment to determine the extent to which both of the theories apply in the context of economic turmoil and transition of a post-socialist country. Although Germany's reunification is clearly an exceptional case, we argue that it nonetheless—and precisely for that reason—provides an excellent set-up to assess the validity of both theories empirically.

3 Institutional Background

In this section, we describe the institutional background of the German reunification and the development of higher education in both German countries. As it will become clear, both crucial assumptions of the identification strategy of our empirical analysis are fulfilled: *a)* the German reunification was unexpected and

thus any anticipation effects are very unlikely, and *b*) higher education in the GDR was highly influenced by the political system—to a varying extent across fields of study—and adapted to West German standards after reunification.

3.1 The German Reunification

Germany's reunification came very unexpectedly. Within less than a year, a series of unprecedented events ultimately led to the German reunification. The process started with the “peaceful revolution” in the GDR in autumn 1989 when the dissatisfaction among the population—on display in public demonstrations—had culminated into a political crisis. The fall of the Berlin wall on November 9, 1989 has to be viewed in this light as an effort by the GDR government to end this crisis. However, the process which had started could not be stopped: the government resigned and democratic elections were held on March 18, 1990. The Monetary, Economic and Social Union came into force on July 1, 1990; and Germany was ultimately reunified on October 3, 1990.

Initially, the widespread opinion was that after reunification, East Germany would be able to quickly catch up to West Germany in terms of economic performance.¹ The comparative advantage over other Central and Eastern European countries was believed to lie exactly in the fact of reunification: East Germany received well-functioning legal and welfare systems, an orderly privatization process, generous welfare benefits, and infrastructure investment (Snower and Merkl, 2006). This was financed through sizeable fiscal transfers from West to East Germany: Uhlig (2008) reports a total net transfer of € 940 billion from West to East Germany between 1991 and 2003. Although these transfers continue, the convergence between East and West Germany has been rather unsuccessful, see Table 1. A number of economic indicators show that almost 20 years after reunification, there are still substantial differences between the two formerly separated parts of Germany. After an initial period of catch-up, the differences appear to be rather stable since the mid-1990s.

Figure 1 depicts migration flows of Germans between East and West Ger-

¹There have been also rather sceptical forecasts, see, e.g., Barro (1991).

many, and vice versa, from 1957 to 2008.² In any given year, the number of migrants from East to West Germany exceeded the number of migrants who moved in the opposite direction. While in the late 1950s and the early 1960s a large number of individuals migrated from East to West Germany, this stopped when the Berlin wall was built and the border was essentially closed. But immediately after the fall of the Berlin wall, i.e., in 1989 and 1990, a huge wave of East-to-West migration took place. In this period, roughly 600,000 East Germans moved to West Germany, corresponding to about 3.7 percent of the population of the former GDR (Heiland, 2004). Afterwards, East-to-West migration rates fell sharply until 1996; and also considerable West-to-East migration can be observed. Therefore, net migration rates substantially decreased until 1997, when East-to-West migration rates increased again. Between 2001 and 2003, the net migration from East to West Germany was roughly 0.5 percent (70,000 people) of the population per annum (Burda, 2006; Uhlig, 2006). East-to-West migration is especially concentrated among individuals aged between 18 and 25 years, and most migrants stem from rural areas or smaller cities. As a result of these varying but persistent migration streams from East to West Germany, the workforce of East Germany shrank by roughly 1.2 million (15 percent) between 1991 and 2004 (Burda, 2006).

3.2 Higher Education in Germany

Higher education in both parts of Germany has a common past and common roots.³ It started in the late fourteenth century when the oldest universities were found, both in the territory of what in 1949 became the Federal Republic of Germany (FRG) as well as in the territory of what in 1949 became the GDR.⁴ Higher education afterwards developed into a flagship of Germany and was internationally recognized. Important developments took place in the course of the nineteenth century as the “Humboldtian University” became the paradigm of German higher education—although it was nowhere fully realized. Among its cornerstones

²Note that Figure 1 does not include Berlin from 2000 to 2008. This very likely explains the sharp drop in West-to-East migration between 1999 and 2000, and also the smaller drop in East-to-West migration in that period.

³See, e.g., de Rudder (1997) for a more detailed description of the development of higher education in Germany (with a particular focus on the development in East Germany).

⁴For instance, the University of Heidelberg was founded in 1386 and the University of Erfurt in 1392.

were the principles of freedom of research, teaching and study, the unity of research and teaching, and the institutional autonomy in academic affairs.

When the National Socialist came into power in 1933, the decline of German higher education began. Academic freedom and institutional autonomy were largely abolished. All Jewish professors and all other who would not cooperate with the new regime were dismissed and persecuted. Simultaneously, Nazi followers were appointed to faculty positions and Nazi doctrines permeated the academy. Six years until World War II, however, were insufficient to complete the Nazification of higher education in Germany. When the war had started, universities were of no particular interest to the rulers anymore, despite of natural and technical sciences which became part of the war effort.

After World War II higher education in East and West Germany developed quite differently—as the political and economic systems of the to newly established and separated countries did. In West Germany, the FRG was founded in 1949 and universities were largely restored to their conditions prior to 1933. This only changed during the student movement in the late 1960s, when also the demand for university graduates had increased. As a consequence, higher education in the FRG underwent an expansion as well as structural and curricular changes. Pressure for further reforms arose in the late 1980s when higher education had run into severe problems: it was increasingly overcrowded, understaffed and underfunded. Government influence had grown and institutional autonomy had weakened, but by no means to a comparable degree as in the GDR (see below). Every person in the FRG had the (basic) right to study at a university of his or her choice as long as the requirements—sufficient education at secondary school—were met. In practice this right might be restricted due to insufficient allocation of university places. Since 1977 there has been a compulsory offer of 800,000 university places. With demand exceeding this offer, restricted admission in the eleven most popular courses was established (*numerus clausus*) and students who would not find a place at the desired university were distributed by a central organization to other universities. A further restriction to access to university education may have been that full-time university education was by far the most common and predominant form. Part-time or distance studies were hardly carried out.

Higher education in the GDR was highly centralized under the authority and

control of the Politburo of the Socialist Unity Party and the ministry in Berlin. On the other hand, it was highly fragmented: alongside the old universities, a large number of small and highly specialized university-level higher education institutions were established. In effect, there was virtually no academic freedom in either teaching or research. For instance, research programs, projects and publications had to be approved. Moreover, admission to university was restricted (Federal Ministry of Intra-German Relations, 1990). The number of university places was planned in accordance with estimated long-run labor demand. Those restrictions were already implemented at secondary school: only a certain number of students (5-10 percent) were eligible to do the general qualification for university entrance. This implied that there was no great discrepancy between supply of university places and demand of students. If backlogs still occurred, those students would be favored who had already done a practical year either in the industry or at the army service. Backlogs for certain university courses were met by “redirection-talks.”

The political system of the GDR also influenced curricula in higher education. The most direct evidence are the compulsory studies of Marxism-Leninism. Every student had to undergo a number of courses in this subject—regardless of the major or the educational institution they were enrolled in. These studies included, among other things, courses in Marxism-Leninism, in Russian and another language, and in athletics. It was not only obligatory but also identical for every student.⁵ While its content and aims remained rather constant since the 1950s, the share increased substantially over time (Rüther, 1994). The overall aim of Marxism-Leninism was to indoctrinate the students as much as possible. Students therefore had to participate and to pass exams, in order to ensure that the contents were studied. The results of these exams had great impact on the status of the student. For example, the decision whether or not students would receive a scholarship was based on these results. In addition to Marxism-Leninism, university education in the GDR included other courses which were influenced by the socialist regime—importantly, to a varying degree across fields of study.

Table 2 shows the variance in the influence of the political system across fields of study. It is based on an assessment of available curricula from various

⁵The curriculum of Marxism-Leninism was identical. The specific hours and shares, however, varied across fields of study, see below.

sources.⁶ The share of courses in Marxism-Leninism ranges from roughly 20 percent in fields of study which are not related at all to its contents (e.g., natural sciences, engineering) to 30 percent and more in fields of studies which are either related to its economic or legal content (economics, law) or to its linguistic content (cultural sciences, philology). But also other courses—which are not part of the compulsory studies—were influenced by the socialist regime; and the degree of influence varied to a larger extent in this regard. While, for instance, the share of such courses was virtually zero in medical sciences and only around 5 percent in natural and technical sciences, it was more than 10 percent in law and history and even larger in economics (more than 20 percent). Therefore, the overall picture looks pretty much as one would have expected *a priori*: the influence of the socialist regime was relatively moderate in fields of study such as natural sciences, engineering and medical sciences (around 20 to 25 percent), while the influence was particularly high in fields of study such as law, history and economics (from roughly 40 to more than 50 percent).

After 40 years of separation into two distinct German countries, East German higher education had therefore become virtually incompatible with the West German system. Both systems had developed far apart until reunification; the Iron Curtain was also an academic borderline (de Rudder, 1997). The socialist regime of the GDR influenced the curricula in university education. Importantly, a quantitative assessment of the degree to which this was the case shows a substantial variation across fields of study. The German reunification came very unexpectedly and can thus be regarded as a natural experiment in our context: After a series of unprecedented events in the course of 1989 and 1990, ultimately leading to the German reunification, higher education in Germany had to be reunified as well—more or less from one day to another. The constitutional and legal situation required that the formal structures and new rules regulating higher education in the FRG were introduced in East Germany. This process was a rather top-down approach as expertise, direction and leadership came largely from the West (de Rudder, 1997). West Germany's system of higher education has been more or less imported to East Germany.

⁶The sources are available from the authors upon request.

4 Empirical Approach

In order to test the two theories against each other, we adapt the widely used Mincerian earnings equation (Mincer, 1974) and put it into the frame work of a difference-in-differences approach. More specifically, we restrict our analysis to university graduates and exploit the fact that the ideology of the former GDR had a different degree of influence on university curricula across fields of study. This variation provides us an identification condition. Formally, we have:

$$\ln Y_i = \alpha + X_i\beta + \gamma_1 \text{major}_i + \gamma_2 \text{east}_i + \gamma_3 \text{east}_i \times \text{major}_i + \varepsilon_i, \quad (1)$$

where the dependant variable is the logarithm of earnings. The vector X_i includes other control variables such as experience and gender. The variables on region and fields of study are of special interest to us.

More specifically, the variable “east” indicates the region where the university degree was obtained (1 for East Germany and 0 otherwise) and the variable “major” indicates the degree of influence of the socialist regime in the given field of study (defined between 0 and 1, where 1 indicates the maximum influence). We calculate the degree of influence across fields of study based on the shares reported in Table 2, and adopt two definitions: *definition 1* uses the total amount (normalized between 0 and 1), and *definition 2* uses only the fraction of other courses in addition to the compulsory studies of Marxism-Leninism (again normalized between 0 and 1).

We are particularly interested in the coefficient of the interaction term of the two variables “east” and “major”. If the signaling theory held, the coefficient of the interaction term would be close to zero. However, if the human capital theory was valid, the impact of major and thus the interaction term would be (significantly) negative, because after reunification the knowledge obtained in majors which had been heavily influenced by the socialist ideology would have depreciated faster than that obtained in other majors.

Additionally, we run similar regressions separately for individuals from East and West Germany:

$$\ln Y_i = \alpha + X_i\beta + \gamma_1 \text{major}_i + \varepsilon_i. \quad (2)$$

We also test the validity of the underlying assumption of the two opposing ap-

proaches in this framework. Under the signaling assumption, the coefficients of “major” would be similar for both East and West Germany. However, if the human capital theory was valid, the impact of “major” would be smaller in East Germany.

5 Data

We use data from the German microcensus which is the official representative statistic of the German population, involving one percent of all households. Households are annually interviewed and have the same probability of being selected. Once selected, a household stays in the sample for four years. A quarter of the households are therefore replaced between two consecutive years. However, we are not able to trace individuals over time and thus treat our data as repeated cross-sections.

The purpose of the microcensus is to provide valid statistical information on the German population with regard to the social and economic situation as well as on employment, unemployment and education. Central to our approach is the field of study of university graduates. We thus use data collected in 1991, 1993, 1995 and 1996 as information about the field of study of university graduates is only available for those years.⁷

Our analysis focuses on male university graduates who are German citizens and are regularly employed, i.e., we drop self-employed, civil servants, apprentices and military personnel from our sample. We apply varying age restrictions to ensure that the university graduates in our sample have obtained their degree before the German reunification. More specifically, we require that individuals were at least 30 years old when the Berlin wall fell in 1989. Individuals are furthermore required to be at most 55 years old in any year to avoid difficulties with accounting for the decision to (early-)retire. Age restrictions in our sample therefore vary from 32–55 years in 1991 to 37–55 years in 1996, and for the years in between accordingly. Finally, we drop individuals with missing information in important characteristics, and we drop the top and bottom one percent in terms of earnings.

An important drawback of our data is that we only observe the current place

⁷Data for 2003, 2004, 2005 and 2006 are not yet included in our analysis.

of residence, i.e., we only observe whether the individual currently lives in East or West Germany. Ideally, we would also need the information about the part of Germany where the degree was obtained. However, we use information about educational and vocational attainment to infer the place of residence before the German reunification—at least to some extent. More specifically, we use information about educational and vocational degrees which were specific to the GDR system and reclassify accordingly. Unfortunately, we are only able to reclassify 23 individuals in our sample as (former) East Germans.

Table 3 displays descriptive statistics of our sample by year of the microcensus. In total, we have information on 14,080 individuals in our sample. The number of observations per year is slightly decreasing over time, probably due to the age restrictions which become more restrictive over time. This also leads to an increasing average age and, hence, increasing average potential experience. In contrast, the fraction of individuals living in East Germany is decreasing over time. We already discussed the varying but persistent migration streams from East to West Germany. With respect to marital status and type of work, the characteristics are on average virtually constant over time. One exception is the share of individuals in marginal employment: it roughly triples between 1995 and 1996, but it is still very low (1.8 percent).

The microcensus offers information on the field of study of the university graduates in our sample. Table 3 shows that the fraction of individuals is virtually constant over time. We distinguish seven broadly defined fields of study. Among those, there are four fields with a relatively large share of graduates in our sample: *a*) technical sciences, engineering; *b*) natural sciences, mathematics; *c*) economics, law, history; and *d*) cultural sciences, arts, sports. The respective shares in these fields vary between 16 and 24 percent. About 10 percent of the graduates in our sample hold a degree in medical sciences, about 5 percent in agricultural sciences, and only slightly more than 2 percent in literature and philology.

Based on this classification and the information about the degree to which the socialist regime has influenced the respective field (cf. Table 2), we calculate the degree of influence according to the two definitions as described in Section 4. Figure 2 displays the respective values for the two alternative definitions across the seven fields of study. In both definitions, “economics, law, history” is the field of study which is influenced to the largest extent by the socialist regime. In con-

trast, "medical sciences" is influenced to a relative small degree.⁸ The other fields of studies lie between these two extreme cases. However, also some differences between the two alternative definitions can be seen. While the degree of influence is larger according to definition 1 than it is according to definition 2 in "natural sciences, mathematics", "literature, philology", and "cultural sciences, arts, sports", it is the other way around in "technical sciences, engineering" and "agricultural sciences".

6 Results

Below we describe our empirical results based on *a*) a difference-in-differences approach and *b*) separate regressions for East and West Germany. Crucial in both frameworks is the variable "major" whose two alternative definitions and respective distributions have already been addressed.

Our first set of results uses definition 1 of the variable "major". This definition includes the fraction of the total amount of regime-related courses, i.e., Marxism-Leninism as well as other courses. Table 4 displays the results of the difference-in-differences approach in this framework. As outlined above, our main interest is on the interaction term of the two variables "east" and "major". This coefficient estimate is negative in all years, although not significantly different from zero at any time, and virtually zero in 1996. Based on these results, it would therefore be difficult to judge in favor or against one of the two approaches towards education.

This picture is reinforced by Table 5 which displays the coefficient estimates of separate regressions for East and West Germany. Similarly to our previous results, the difference between the coefficient estimates for East and West Germany is negative in all years, i.e., the coefficient estimates for regime-related courses are lower in East Germany than in West Germany. This indicates lower returns in fields of study which were highly influenced by the political regime, but the differences in the coefficient estimates are very likely also not significantly different from zero in any year. Again, it is thus not possible to reject one or the other approach towards education.

⁸Note that the values are normalized between 0 and 1. Therefore, also "medical sciences" is influenced to some extent, yet to the smallest—corresponding to a value of 0.

Using the alternative definition of the variable “major”, which only includes the extra amount of courses *in addition* to the compulsory courses in Marxism-Leninism, yields however a more clear-cut picture. Table 6 displays the results of the difference-in-differences approach in this framework. Again, the coefficient estimate of the interaction term is negative in all years. But—with the exception of 1991—the estimates are significantly different from zero, indicating significantly lower returns in fields of study which were highly influenced by the socialist regime. Furthermore, we observe that the estimated coefficient becomes less negative over time. This may indicate that the effect fades out over time—for instance, because work experience in the market economy becomes more and more important. These results can be therefore seen as evidence in favor of the theory of human capital.

Again, separate regressions for East and West Germany reinforce the results of the difference-in-differences approach. Table 7 shows that the difference between the coefficient estimates for East and West Germany is negative in all years, and that these differences are of very similar magnitude as the estimated coefficients on the interaction term in the previous framework.

Hence, we find evidence supporting the theoretical predictions of the theory of human capital, although this evidence only appears when using definition 2 of the variable measuring the extent to which the socialist regime had influenced different fields of study. But this is what one might have suspected from the very beginning: the studies of Marxism-Leninism were not only obligatory, but also identical for every student—importantly, across different fields of study. Therefore, the variance in the influence of the socialist regime through other (i.e., additional) courses appears much more important than the variance through Marxism-Leninism itself. The latter variation may simply reflect varying total hours across different fields of study.

7 Conclusions

This paper adds to the existing literature on the debate between Becker’s theory of human capital and Spence’s signaling approach towards education. It makes use of a clear natural experiment and exploits the variation in the influence of the

political system on curricula across fields of study in university education.

Our study focuses on Germany, where the reunification of the two formerly separated parts of the country in 1990 serves as a natural experiment. As this major historical event came very unexpectedly, any anticipation effects are more than unlikely. The main idea underlying our approach is that some fields of study were heavily influenced by the political system of the GDR (e.g., law, economics, history), whereas other fields of study were influenced to a smaller extent (e.g., medical sciences, natural sciences, technical sciences). We exploit this variation to empirically test the theoretical predictions of the two opposing approaches towards education. Put differently, it may not just be a coincidence that the current German chancellor, Dr. Angela Merkel, who obtained her degree and doctorate in the GDR, graduated in natural sciences (i.e., physics).

Our results support the theory of human capital. We find that the value of university degrees obtained in the GDR which were highly influenced by the socialist regime was substantially depreciated after reunification when compared to degrees in fields of study which were influenced to a smaller extent. Furthermore, our results indicate that these differences across fields of study seem to fade out over time. This may reflect that work experience in the market economy becomes more and more important over time. Importantly, the evidence in favor of Becker's human capital theory only appears when we measure the extent to which fields of subjects have been influenced by the regime focusing on courses *in addition* to the compulsory studies of Marxism-Leninism. We thus conclude that the variance in the influence of the socialist regime through other (i.e., additional) courses appears much more important than the variance through Marxism-Leninism itself.

There are at least two potential threats to our identification strategy. Firstly, our data only includes information about the individuals' current place of residence. Ideally, we would also need information about the part of Germany where the university degree was obtained. There are varying but persistent migration streams within Germany, in particular from East to West Germany and in the beginning of the 1990s. We therefore expect some of the individuals to be wrongly classified as West Germans (and *vice versa* to a smaller extent). A remedy to this potential threat, which is based on the individuals' educational background available in our data, does unfortunately only reclassify very few individuals. Secondly, our approach does so far not address the selection process into university education and

into the different fields of study. This selection process, however, may have been different between East and West Germany before reunification. Future versions of this paper will therefore take both of these potential threats into account.

References

- Albrecht, J. W. (1981). A Procedure for Testing the Signalling Hypothesis. *Journal of Public Economics* 15(1), 123–132.
- Albrecht, J. W. and J. C. van Ours (2006). Using Employer Hiring Behavior to Test the Educational Signaling Hypothesis. *Scandinavian Journal of Economics* 108(3), 361–372.
- Barro, R. J. (1991, May 3). Eastern Germany's Long Haul. *Wall Street Journal*. Section A, p. 10.
- Becker, G. S. (1962). Investment in Human Capital: A Theoretical Analysis. *Journal of Political Economy* 70(5), 9–49.
- Becker, G. S. (1993). *Human Capital: A Theoretical and Empirical Analysis with a Special Reference to Education* (3rd ed.). Chicago: University of Chicago Press.
- Burda, M. C. (2006). Factor Reallocation in Eastern Germany after Reunification. *American Economic Review* 96(2), 368–374.
- de Rudder, H. (1997). The Transformation of East German Higher Education: Renewal as Adaptation, Integration and Innovation. *Minerva* 35(2), 99–125.
- Federal Ministry of Intra-German Relations (Ed.) (1990). *Materialien zur Lage der Nation: Vergleich von Bildung und Erziehung in der Bundesrepublik Deutschland und in der Deutschen Demokratischen Republik*. Cologne: Verlag Wissenschaft und Politik.
- Heiland, F. (2004). Trends in East-West German Migration from 1989 to 2002. *Demographic Research* 11(7), 173–194.
- Jaeger, D. A. and M. E. Page (1996). Degrees Matter: New Evidence on Sheepskin Effects in the Returns to Education. *The Review of Economics and Statistics* 78(4), 733–740.
- Kane, T. J. and C. E. Rouse (1995). Labor-Market Returns to Two- and Four-Year College. *American Economic Review* 85(3), 600–614.
- Kroch, E. A. and K. Sjoblom (1994). Schooling as Human Capital or a Signal: Some Evidence. *Journal of Human Resources* 29(1), 156–180.
- Lang, K. and D. Kropp (1986). Human Capital Versus Sorting: The Effects of Compulsory Attendance Laws. *Quarterly Journal of Economics* 101(3), 609–624.
- Lange, F. (2007). The Speed of Employer Learning. *Journal of Labor Economics* 25(1), 1–35.
- Mincer, J. (1974). *Schooling, Experience, and Earnings*. New York: Columbia University Press.
- Riley, J. G. (1979). Testing the Educational Screening Hypothesis. *Journal of Political Economy* 87(5), S227–S252.
- Rüther, B. (1994). Das marxistisch-leninistische Grundlagenstudium: Eine problematische Form fachübergreifenden Lehrens und Lernens. In L. Huber, J. H. Olbertz, B. Rüther, and J. Wildt (Eds.), *Über das Fachstudium hinaus: Berichte zu Stand und Entwicklung fachübergreifender Studienangebote an Universitäten*, Blickpunkt Hochschuldidaktik, pp. 71–96. Weinheim: Deutscher Studien Verlag.
- Snower, D. J. and C. Merkl (2006). The Caring Hand that Cripples: The East German Labor Market after Reunification. *American Economic Review* 96(2), 375–382.
- Spence, A. M. (1973). Job Market Signaling. *Quarterly Journal of Economics* 87(3), 355–374.
- Spence, A. M. (1974). *Market Signaling: Informational Transfer in Hiring and Related Screening Processes*. Cambridge: Harvard University Press.

- Taubman, P. J. and T. J. Wales (1973). Higher Education, Mental Ability, and Screening. *Journal of Political Economy* 81(1), 28–55.
- Tyler, J. H., R. J. Murnane, and J. B. Willett (2000). Estimating the Labor Market Signaling Value of the GED. *Quarterly Journal of Economics* 115(2), 431–468.
- Uhlig, H. (2006). Regional Labor Markets, Network Externalities and Migration: The Case of German Reunification. *American Economic Review* 96(2), 383–387.
- Uhlig, H. (2008). The Slow Decline of East Germany. NBER Working Paper 14553, National Bureau of Economic Research, Inc, Cambridge, MA.
- Wise, D. A. (1975). Academic Achievement and Job Performance. *American Economic Review* 65(3), 350–366.
- Wolpin, K. I. (1977). Education and Screening. *American Economic Review* 67(5), 949–958.

Table 1: East German Convergence, 1991–2008

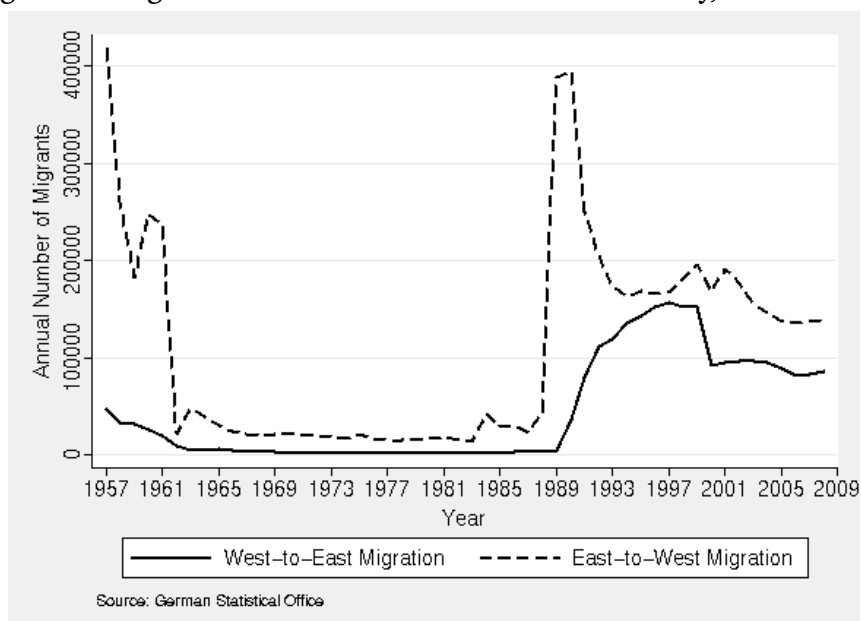
Year	Consumption	Nominal Wages	Labor Productivity	GDP per capita	Unemployment rate
1991	62	58	44 ^a	43	165
1992	67	68	57 ^a	50	225
1993	73	75	67 ^a	59	193
1994	75	77	70 ^a	64	174
1995	78	79	71 ^a	67	163
1996	79	80	72 ^a	68	168
1997	79	80	72 ^a	68	177
1998	80	80	68	67	187
1999	81	81	69	68	194
2000	81	81	70	67	220
2001	80	81	72	67	235
2002	81	81	74	69	226
2003	81	81	74	69	216
2004	80	81	74	70	213
2005	80	82	74	69	186
2006	80	82	74	70	189
2007	80	82	75	70	200
2008	n/a	81	76	71	203

Source: Federal Statistical Offices, Federal Employment Agency.

Notes: In percent of West German Value. West Germany excludes Berlin; East Germany includes Berlin.

^a As reported in Burda (2006).

Figure 1: Migration Between East and West Germany, 1957–2008.



Notes: From 1957 to 1999, East Germany includes Berlin. However, Berlin is not included at all from 2000 to 2008. Preliminary estimate for 2008.

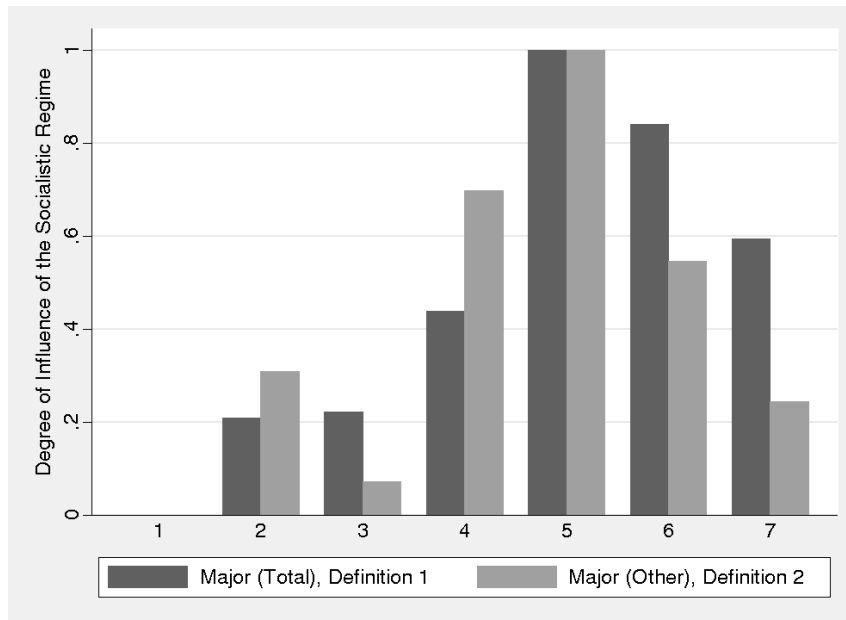
Table 2: Influence of the Socialist Regime Across Fields of Study

Field of study	Marxism-Leninism	Other courses	Total
Medical sciences			
Medical science	17.1	1.4	18.5
Technical sciences, engineering			
Agricultural engineering	18.0	4.8	22.8
Process engineering	18.6	5.4	24.0
Electronic engineering	20.3	6.8	27.1
Natural sciences, mathematics			
Mathematics	22.6	2.4	25.0
Agricultural sciences			
Plant production	20.2	11.1	31.3
Economics, business administration			
Economics	33.8	22.4	56.2
Law, history, philosophy etc.			
Law	29.8	10.5	44.4
History	29.4	12.9	42.3
Literature, philology			
German language and literature studies	34.0	9.0	43.0
Cultural sciences, arts, sports			
Dramatics	31.0	4.8	35.8

Source: Various sources (available from the authors upon request).

Notes: In percent of total time. Calculations are based on the respective curriculum.

Figure 2: Degree of Influence of the Socialist Regime Across Fields of Study.



Notes: The seven fields of study are as follows: (1) medical sciences; (2) technical sciences, engineering; (3) natural sciences, mathematics; (4) agricultural sciences; (5) economics, law, history; (6) literature, philology; (7) cultural sciences, arts, sports. Calculations are based on the shares reported in Table 2.

Table 3: Descriptive Statistics (1991–1996)

	1991	1993	1995	1996
Age	41.9538 (6.9592)	43.3354 (6.5001)	44.2941 (5.7995)	44.8758 (5.4832)
East Germany	0.4257 (0.4945)	0.3967 (0.4893)	0.3467 (0.4760)	0.3542 (0.4784)
Potential Experience	18.0871 (7.0011)	19.4263 (6.5315)	20.4342 (5.8609)	21.0078 (5.5430)
Years of schooling	17.8666 (0.5533)	17.9090 (0.4570)	17.8599 (0.5739)	17.8681 (0.5497)
Single	0.1443 (0.3514)	0.1410 (0.3481)	0.1380 (0.3449)	0.1378 (0.3448)
Married	0.8026 (0.3981)	0.8023 (0.3983)	0.7976 (0.4019)	0.8035 (0.3974)
Widowed	0.0053 (0.0728)	0.0058 (0.0760)	0.0064 (0.0795)	0.0043 (0.0658)
Divorced	0.0478 (0.2133)	0.0509 (0.2198)	0.0581 (0.2340)	0.0543 (0.2267)
White collar	0.9845 (0.1235)	0.9842 (0.1246)	0.9758 (0.1537)	0.9792 (0.1427)
Blue collar	0.0155 (0.1235)	0.0158 (0.1246)	0.0242 (0.1537)	0.0208 (0.1427)
Marginal employment	0.0051 (0.0711)	0.0036 (0.0599)	0.0051 (0.0715)	0.0177 (0.1319)
Major (Total)	0.4525 (0.3418)	0.4587 (0.3385)	0.4466 (0.3383)	0.4581 (0.3426)
Major (Other)	0.3982 (0.3581)	0.3991 (0.3540)	0.3847 (0.3538)	0.4015 (0.3575)
Medical sciences	0.0996 (0.2995)	0.0854 (0.2796)	0.0926 (0.2899)	0.0944 (0.2924)
Technical sciences, engineering	0.2357 (0.4245)	0.2444 (0.4298)	0.2363 (0.4249)	0.2425 (0.4286)
Natural sciences, mathematics	0.2055 (0.4041)	0.2054 (0.4041)	0.2290 (0.4203)	0.1999 (0.4000)
Agricultural sciences	0.0602 (0.2379)	0.0536 (0.2253)	0.0484 (0.2147)	0.0537 (0.2255)
Economics, law, history etc.	0.2182 (0.4131)	0.2170 (0.4123)	0.2091 (0.4067)	0.2220 (0.4156)
Literature, philology	0.0201 (0.1402)	0.0224 (0.1480)	0.0236 (0.1518)	0.0224 (0.1479)
Cultural sciences, arts, sports	0.1608 (0.3674)	0.1717 (0.3772)	0.1610 (0.3676)	0.1652 (0.3714)
Obs.	3,937	3,617	3,305	3,221

Source: Microcensus, own calculations.

Notes: Sample of university graduates. Standard deviation in brackets.

Table 4: Difference-in-Differences Major, Definition 1 (1991–1996)

	1991	1993	1995	1996
Experience	0.0355*** (0.0058)	0.0232*** (0.0072)	0.0359*** (0.0095)	0.0143 (0.0106)
Experience ² /100	-.0671*** (0.0151)	-.0296* (0.0177)	-.0615*** (0.0221)	-.0153 (0.0241)
Years of education	0.0403*** (0.011)	0.0408*** (0.0117)	0.0333*** (0.0106)	0.0291** (0.0114)
Major (Total)	-.0313 (0.0232)	-.0343 (0.024)	-.0795*** (0.0251)	-.0642** (0.0252)
East	-.0355 (0.1328)	-.3361 (0.3551)	0.044 (0.1634)	-.4969*** (0.1796)
East × Major (Total)	-.0541 (0.0419)	-.0540 (0.0407)	-.0606 (0.046)	-.0008 (0.0474)
Obs.	3,937	3,617	3,305	3,221
R^2	0.6097	0.4195	0.3632	0.3708

Source: Microcensus, own calculations.

Notes: Sample of university graduates. Dependent variable: log income. Robust standard errors in brackets. Additional controls: marital status, state dummies, blue/white collar, marginal employment.

*** significant at 1%; ** significant at 5%; * significant at 10%.

Table 5: Returns to Major by Region, Definition 1 (1991–1996)

	1991		1993		1995		1996	
	West	East	West	East	West	East	West	East
Experience	0.0372*** (0.0077)	0.0071 (0.0086)	0.0203** (0.0098)	0.0075 (0.0102)	0.0359*** (0.0126)	-0.0005 (0.0155)	-0.0028 (0.014)	0.016 (0.0167)
Experience ² /100	-0.0488** (0.0206)	-0.0218 (0.0216)	-0.0090 (0.0245)	-0.0101 (0.0247)	-0.0480 (0.03)	-0.0007 (0.0345)	0.0363 (0.0325)	-0.0376 (0.0368)
Years of education	0.0191 (0.0379)	0.033*** (0.0115)	0.095** (0.0449)	0.0257** (0.0118)	0.0888** (0.0403)	0.0173 (0.0107)	0.0312 (0.0253)	0.0194 (0.0125)
Major (Total)	-0.0250 (0.0226)	-0.0738** (0.034)	-0.0310 (0.0239)	-0.0835*** (0.0316)	-0.0746*** (0.0251)	-0.1383*** (0.0378)	-0.0604** (0.0251)	-0.0609 (0.0394)
Obs.	2,261	1,676	2,182	1,435	2,159	1,146	2,080	1,141
R ²	0.2337	0.2095	0.1906	0.1297	0.1781	0.1820	0.1973	0.1310

Source: Microcensus, own calculations.

Notes: Sample of university graduates. Dependent variable: log income. Robust standard errors in brackets. Additional controls: marital status, state dummies, blue/white collar, marginal employment.

*** significant at 1%; ** significant at 5%; * significant at 10%.

Table 6: Difference-in-Differences Major, Definition 2 (1991–1996)

	1991	1993	1995	1996
Experience	0.0346*** (0.0058)	0.0225*** (0.0072)	0.0362*** (0.0096)	0.0139 (0.0106)
Experience ² /100	-.0653*** (0.0151)	-.0285 (0.0177)	-.0626*** (0.0222)	-.0149 (0.0241)
Years of education	0.0454*** (0.0109)	0.0422*** (0.0116)	0.0336*** (0.0106)	0.029** (0.0115)
Major (Other)	0.0843*** (0.022)	0.0775*** (0.0225)	0.0419* (0.024)	0.0465* (0.024)
East	-.0058 (0.1333)	-.2811 (0.3545)	0.0552 (0.1671)	-.4595*** (0.1734)
East × Major (Other)	-.0278 (0.0397)	-.1586*** (0.0389)	-.1267*** (0.0442)	-.0939** (0.0446)
Obs.	3,937	3,617	3,305	3,221
R^2	0.6106	0.4211	0.3601	0.3700

Source: Microcensus, own calculations.

Notes: Sample of university graduates. Dependent variable: log income. Robust standard errors in brackets. Additional controls: marital status, state dummies, blue/white collar, marginal employment.

*** significant at 1%; ** significant at 5%; * significant at 10%.

Table 7: Returns to Major by Region, Definition 2 (1991–1996)

	1991		1993		1995		1996	
	West	East	West	East	West	East	West	East
Experience	0.0361*** (0.0077)	0.0065 (0.0086)	0.0201** (0.0097)	0.0064 (0.0103)	0.0366*** (0.0127)	-0.0011 (0.0156)	-0.0038 (0.014)	0.0167 (0.0167)
Experience ² /100	-0.0465** (0.0205)	-0.0205 (0.0215)	-0.0091 (0.0244)	-0.0078 (0.0248)	-0.0504* (0.0301)	0.0003 (0.0349)	0.038 (0.0326)	-0.0396 (0.0367)
Years of education	0.02 (0.0376)	0.0381*** (0.0114)	0.1006** (0.0447)	0.0266** (0.0117)	0.0914** (0.0398)	0.0176 (0.0107)	0.0318 (0.0259)	0.0191 (0.0125)
Major (Other)	0.0838*** (0.0215)	0.0609* (0.0323)	0.0744*** (0.0224)	-0.0762** (0.0308)	0.0421* (0.024)	-0.0851** (0.0366)	0.0437* (0.0239)	-0.0422 (0.0369)
Obs.	2,261	1,676	2,182	1,435	2,159	1,146	2,080	1,141
R ²	0.2385	0.2087	0.1939	0.1293	0.1758	0.1752	0.1962	0.1299

Source: Microcensus, own calculations.

Notes: Sample of university graduates. Dependent variable: log income. Robust standard errors in brackets. Additional controls: marital status, state dummies, blue/white collar, marginal employment.

*** significant at 1%; ** significant at 5%; * significant at 10%.