Explaining the Low Labor Productivity in East Germany - A Spatial Analysis

Nicola Fuchs-Schündeln and Rima Izem*
Harvard University

April 18, 2008

Abstract

This paper sheds light on the transferability of human capital in periods of dramatic structural change by analyzing the unique event of German Reunification. We explore whether the comparatively low labor productivity in East Germany after reunification is caused by the depreciation of human capital at reunification, or by unfavorable job characteristics. East German workers should have been hit harder by reunification the more specific human capital was. Treating both human capital and job characteristics as unobservables, we derive their relative importance in explaining the low labor productivity by estimating a spatial structural model that predicts commuting behavior across the former East-West border and the resulting regional unemployment rates. The identification of the model is based on the slope of the unemployment rate across the former border: the larger the human capital differences between East and West, the less commuting across the border takes place, and the sharper is the increase of the unemployment rate at the former border. The results indicate that East and West German skills are very similar, while job characteristics differ significantly between East and West. Hence, they suggest that a significant part of the human capital accumulated in the East before 1990 was transferable. (JEL: C15, J24, J61; keywords: transferability of human capital, spatial allocation of labor)

1 Introduction

German reunification provides a unique opportunity to study the transferability of human capital in a period of severe structural changes. According to traditional measures of human capital, like years of schooling or further education, the East German population was

*Nicola Fuchs-Schündeln, Department of Economics, Harvard University, nfuchs@harvard.edu. Rima Izem, Department of Statistics, Harvard University, izem@stat.harvard.edu. We thank Guido Imbens, Matthias Schündeln, Harald Uhlig, and the seminar audiences at the Harvard Statistics Department, Spatial Econometrics Conference 2006 in Rome, the Verein fuer Socialpolitik Annual Conference 2006 in Bayreuth, and Brandeis University for their feedback and suggestions. We thank Susanne Raessler and Katja Wolf from the IAB for wonderful hosting in Nuremberg, and for all their help and feedback with the data; and Anders Hopperstedt from the Center of Geographic Analysis at Harvard for calculating the driving times between counties. Kirk Moore, Kelly Shue, Andreas Fuster, and Linjuan Qian provided excellent research assistantship. This research was partly funded by the William Milton Fund and a research grant by the Wheatherhead Center for International Affairs at Harvard University.

better educated at reunification than was the West German population. If human capital is very general and transferable, e.g. mostly consisting of general problem-solving, language or mathematical skills, the East German population should have fared very well in the new West German labor market. However, the content of education and on the job training might have differed substantially between both countries, and a lot of either job-, industry-, occupation-, or technology-specific human capital should thus have depreciated at reunification.[1]

The analysis of this paper answers questions of broad policy importance. How easily is human capital transferred from an obsolete industry to the next? What is the relationship between depressed and booming regions? German reunification provides a unique opportunity to study these questions. In contrast to other possible case studies, e.g. the car industry in Michigan, or a comparison of Northern and Southern Italy, the German case offers three unique advantages: First and foremost, there exists a clearly defined "border" between the two regions in question, namely the former border between East and West Germany. Second, there is a clear point in time at which we would expect human capital of one region to depreciate if it were specific to the job, occupation, industry, or technology, namely German Reunification in 1990. Last, these two regions offer a very stark contrast. German reunification rendered many East German technologies obsolete. Within four years of reunification, the government only managed to sell around two-thirds of all East German government-owned firms, despite the creation of a special agency in charge of the privatization. Of the privatized firms, around half were liquidated by 1994 anyhow (Grosser, 2003).[2]

Since German reunification in 1990, unemployment rates in East Germany have been stubbornly high. Figure 1 shows the mean unemployment rates by county (*Kreis*) between 1998 and 2004, as well as the former East-West border. There are 439 counties in Germany, of which 326 belong to the former West.[3] The average population size of a county is 188,000. Unemployment rates are calculated as the ratio of people registered as unemployed to the sum of all employees and unemployed.[4] On average, unemployment rates in the East are around twice as high as those in the West.

[1] The distinction between general skills and skills specific to a firm or occupation dates back at least to Becker (1964) and Mincer (1974). Chari and Hopenhayn, 1991, and Violante, 2002, analyze the effect of vintage specific human capital on the diffusion of new technologies and wage inequality, respectively.

[2] The government-owned firms originally provided 4.1 million jobs, while the total population in the East amounted to 17 million people. In 1994, the privatized firms only provided 1.5 million jobs.

[3] During our sample period 1998 to 2004, there was one county reform, involving Hannover. From 2002 on, Hannover is one county, while before it was split into *Stadtkreis* and *Landkreis* Hannover. We treat Hannover as one county throughout, and sum up or build averages over *Stadtkreis* and *Landkreis* data for 1998 to 2001, as appropriate.

[4] This sum includes in addition to the unemployed employees subject to mandatory social insurance contributions, part-time employees, and civil servants, but excludes self-employed, for whom only estimates exist on the county level.

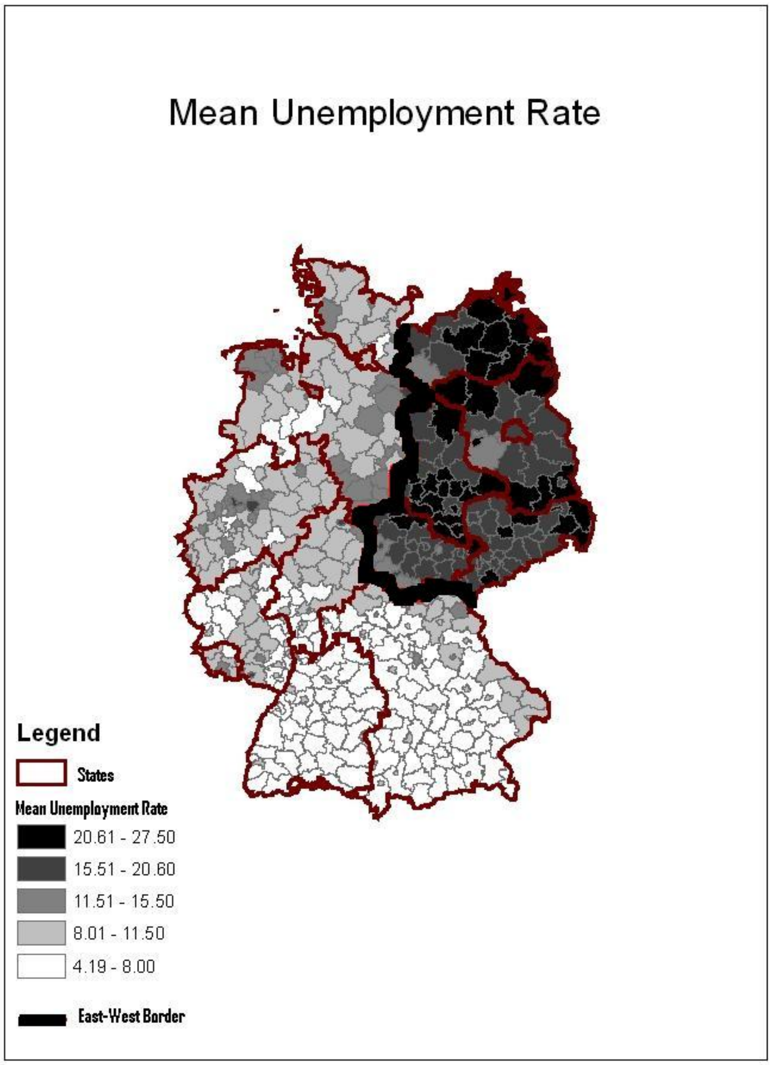

Figure 1: Mean Unemployment Rates in German Counties, 1998 to 2004

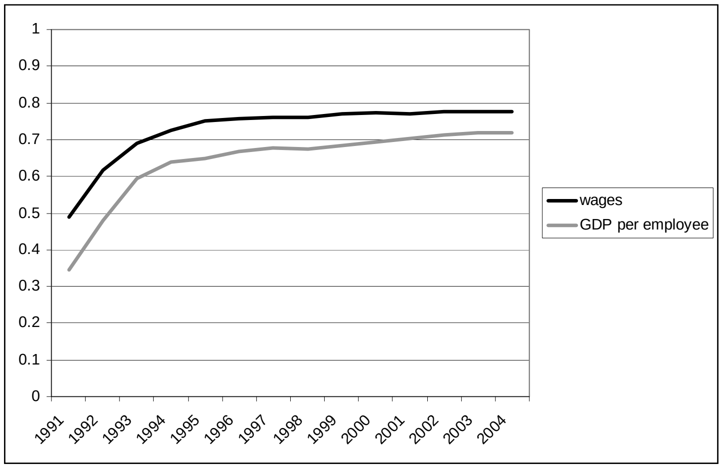

Figure 2: East-West ratios of wages and labor productivity, 1991 to 2004

By now, it is well established that the major cause of the high unemployment rates in the East lies in wages exceeding labor productivity (see e.g. Burda and Hunt, 2001). Figure 2 shows the East-West ratios of wages in addition to the East-West ratios of labor productivity, measured as GDP per employee, from 1991 to 2004. The trend in both ratios has been remarkably similar. There is rapid convergence between East and West until 1995, and from then on convergence has slowed down significantly, or even come to a halt. Most importantly, the East-West ratio of wages is always larger than the East-West ratio of labor productivity, and there is only a small and slow decline in the difference between both. Thus, it seems that wages in the East are too high relative to wages in the West, given the lower labor productivity.[5]

While the gap between wages and labor productivity has been established as the main reason for the high unemployment rates in the East, there is no consensus as to *why* labor productivity remains low in the East. Two different strands of explanations have been brought forward, and the goal of this paper is to differentiate between these two different explanations. The first set of hypotheses has to do with job characteristics, i.e. reasons outside the influence of an individual worker. Possible explanations range from firm sizes (Beer and Ragnitz, 1997), branch structure (Rothfels, 1997), the heterogeneity of factor endowments (Dietrich, 1997), agglomeration effects (Uhlig, 2006; Yellen, 2001), and R&D spending (Felder and Spielkamp, 1998), to managerial and organizational deficiencies (Yellen, 2001; Mallok, 1996; Bellmann and Brussig, 1998; Ragnitz et al., 1998; Müller et al., 1998). While our model treats these job characteristics as a homogeneous factor, the results will shed

[5] Ragnitz (2006) shows that a similar East-West gap exists when using alternative measures of productivity. Funke and Rahn (2002) provide a detailed analysis of the efficiency of firms in East Germany, and find that they are significantly less efficient than West German firms.

some light on which specific components of the job characteristics are of likely importance in explaining the low labor productivity.

A completely different explanation sees the reason for the lower labor productivity in East Germany in worker characteristics. Formal educational levels in the GDR exceeded those of West Germans (see e.g. Klodt, 2000). From the German Socio-Economic Panel, we estimate that the mean years of formal education correspond to 14.2 among labor force participants who lived in East Germany before 1990, and 13.1 among their West German counterparts.[6] Yet, it might be that there are unobserved differences in human capital between East and West German workers. Specific human capital might have depreciated at reunification since it did not match the skill requirements of firms using technologies typically used in West Germany (Ragnitz, 2006). Canova and Ravn (2000) assume that skill levels are on average lower in the East than in the West, claiming that much of the workers' human capital in the East was organization-specific. Burda and Hunt (2001) find that early migrants and commuters to the West received little return to their education, but that the return grew over time to equal the western return by 1999.[7] Using a task-based framework, Spitz-Oener (2007) finds that the level of tasks inputs and the patterns of task changes between 1991 and 1999 were similar between East Germans and West Germans.

We propose a novel method for differentiating between these two explanations, i.e. differences in worker characteristics or differences in job characteristics. Since skills and job characteristics are hard to quantify, they are treated as unobservables and are to be estimated in our model. We estimate the East-West difference of these unobservable characteristics by fitting a spatial economic model to the data. The model predicts the working and commuting behavior of individuals given the unobservables.[8] More precisely, it models the effects of skills and job characteristics on the individual labor productivity, commuting behavior, and county-level unemployment rates. We are able to differentiate between worker and job characteristics as the causes for the low labor productivity because the predictions for commuting across the border differ under each hypothesis, resulting in different slopes of the unemployment rate across the former border. Essentially, if only worker characteristics cause the low labor productivity, then any unemployed worker in the East would not be able to find a job in the West either. On the other hand, if only job characteristics are less favorable in the East, then unemployed East Germans who live close to the border can commute to work in the West, thus depressing the unemployment rates in Eastern bor-

[6] In contrast to the summary statistics shown in Table 18, East and West refer here to the residence before reunification.

[7] Burda and Schmidt (1997) conclude that returns to education in the East were very similar to the returns in the West, even in the early 1990s.

[8] Importantly, the model abstracts from migration. This assumption is discussed in detail in Section 3, and relaxed in Section 6.2.

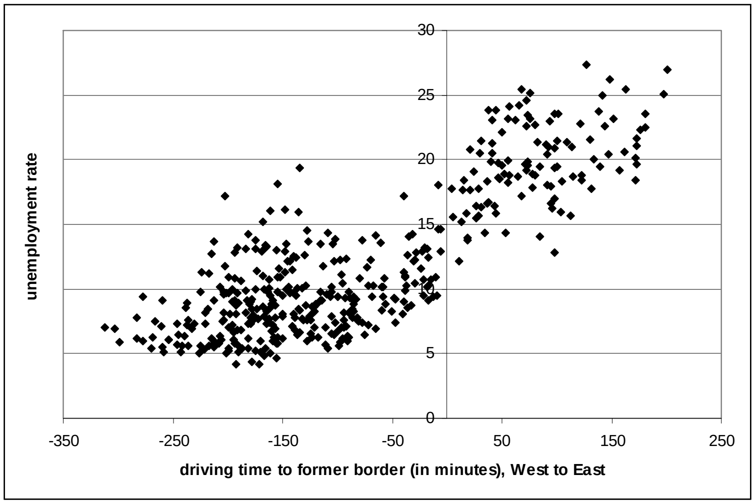

Figure 3: County unemployment rates as a function of driving time to border, 1998 to 2004. Negative time indicates location west of the former border, positive time indicates location east of the former border.

der counties, and increasing the unemployment rates in Western border counties. Figure 3 shows the county unemployment rates as a function of the driving time to the closest point on the former border. This driving time is measured as a negative number for West German counties, and as a positive number for East German counties. We treat Berlin as part of the East, and thus do not count the border around West Berlin as part of the former border.[9] The graph clearly shows that Western counties have lower unemployment rates than Eastern counties. Most importantly, counties at the former East-West border have intermediate unemployment rates. This is confirmed in the regression results of Table 1, in which the unemployment rate is regressed either on a border dummy that takes on the value of 1 if the county lies within 60 minutes driving time of the former border, or directly on driving time to the former border, measured as a positive number in minutes, separately for East and West.

Our model relates to the literature that takes the location of jobs and workers in different markets into account.[10] Tobin (1972) refers to "obsolescent industries and declining areas" when explaining why vacancies and unemployment coexist. Shimer (2007) analyzes the geographical and skill mismatch of unemployed workers and vacancies in a model in which wages adjust to clear regional labor markets, and firms decide how many vacancies to post, but movement of workers between the markets is exogenous. Taking the opposite approach, Lagos (2000) builds a model of the taxicab market in which the spatial location of demand

[9] We provide a robustness check excluding Berlin and the surrounding counties in section 5.

[10] While our model refers purely to geographic labor markets, the literature often refers in addition to markets for different skill levels.

Dependent variable: Unemployment rate	West Germany		East Germany	
West border dummy	2.422*** (0.376)			
East border dummy			-2.457*** (0.575)	
time to border (min)		-0.016*** (0.002)		0.029*** (0.005)
constant	8.603*** (0.160)	11.146*** (0.298)	20.654*** (0.357)	17.282*** (0.509)

Note: Standard errors are in parentheses and are corrected for clustering at the county level. *** indicates significant at the 1% significance level. Border dummy equals one if county lies within 60 minutes of former border. Driving time measured as positive number in both East and West.

Table 1: Regressions of county unemployment rates on border dummies and driving time to border, 1998 to 2004

and supply arises endogenously, but prices are exogenously fixed.

Like Lagos (2000), we assume that wages are exogenous. This seems reasonable in the context of Germany, due to the high rate of unionization and the political pressure to increase wages in the East quickly after reunification (see e.g. Snower and Merkl, 2006). While we assume that the number of jobs and the number of labor force participants in any county is fixed, regional labor supply is still an endogenous variable through the commuting decisions of workers.

Our results indicate that skills do not differ significantly between East and West, while job characteristics in the East are significantly less favorable than those in the West, in both economic and statistical terms. The results thus suggest that a large part of human capital was transferable at reunification. The model captures the spatial trend of the unemployment rate fairly well.

Section 2 describes the various data sets used in the analysis. The model and its calibration are presented in Section 3. Section 4 introduces our estimation methodology, namely the method of simulated moments. Results of the estimation are shown in Section 5. Section 6 analyzes the sensitivity of the results to different assumptions, and cross-checks the results with commuting data. Section 7 rules out some alternative explanations for the observed slope of the unemployment rate across the border by presenting evidence for the crucial assumption of a uniform spatial distribution of factors of production within the East and within the West. Finally, Section 8 concludes.

2 Data

The main data for this project are monthly county level unemployment rates from 1998 to 2004, obtained from the German Institute for Employment Research (IAB). From these data, we build the average county level unemployment rate from 1998 to 2004.[11] Moreover, in the calibration we use data from the IAB on the number of employed people per county of residence, the number of employed people per county of work, the number of unemployed per county of residence, and the number of vacancies posted at the employment agency of the respective county.[12]

We also compare the predicted commuting streams from our model to actual cross-county commuting data from 2001 and 2002. The commuting data cover only employees who are subject to mandatory social insurance contributions (*sozialversicherungspflichtig Beschäftigte*), which make up around 71 percent of all employees. The data also cover weekly commuting, which we do not model, but which according to the data is relatively unfrequent, and seems to depend to a far lesser degree on distance. For these two reasons, we match the spatial distribution of unemployment rates rather than commuting flows directly.

For further evidence, we also use micro data from the German Socio-Economic Panel (GSOEP) rounds 1998 to 2004. The German Socio-Economic Panel is an annual household panel which allows the researcher to follow East and West Germans over time. We identify a person as someone who lived in East Germany before 1990 if the person either belongs to the "East Germany" sample that was added to GSOEP in the spring of 1990, or if the person reports having a GDR-education.[13] Appendix A presents some summary statistics from work force characteristics in East and West based on the GSOEP data, and provides evidence that differences in observable characteristics are very small. The estimations in Section 7.1 aggregate data from GSOEP at the county level. There are four counties for which we do not have any observations in GSOEP. Conditional on having a positive number of observations, the mean number of observations per county over all seven years is 293, and the median 231, with a minimum of 6 and a maximum of 2451.[14]

[11] A time-series analysis of these data shows no major time trends, but significant seasonality. The seasonality pattern is similar for all counties, such that the average is a meaningful summary. Results are available from the authors upon request.

[12] These data are available for 2001. The number of employed people includes employees, civil servants, and self-employed.

[13] The refreshment samples added in 1998 and 2000 do not directly identify the residence of the respondent before reunification, but allows the researcher to deduce this residence from information about education.

[14] To work with county identifiers, we use remote access to GSOEP via soepremote. When we use the data without county identifiers, we work with the 95% random sample of GSOEP that is available for researchers outside of Germany. The only sample restriction that we impose in Section 7.1 is that respondents have to be at least 20 years old. The four counties with no observations are Stadtkreis Zweibrücken, Weiden in der Oberpfalz, Memmingen, and Köthen. GSOEP treats Eisenach as part of the Wartburgkreis. Last, GSOEP allows us to distinguish between East and West Berlin. However, in line with our main analysis, we treat Berlin as part of the East. We repeat all regressions excluding Berlin, and the results are not sensitive to

Last, we analyze aggregate data at the county level on investment subsidies, investment, labor force participation rates, and plant openings. The first three data sets come from the *Bundesamt für Bauwesen und Raumordnung* (various issues), and the latter data are based on microdata from the IAB (*Beschäftigtenstatistik*). The data on investment subsidies cover the period 1999 to 2003, the data on investment the period 1994 to 2002 in five time intervals, the data on labor force participation rate are annual data from 1998 to 2004, and the data on plant openings are annual data from 1996 to 2004.[15]

3 The Model

The model predicts the commuting behavior across counties and the resulting regional unemployment rates based on the worker and job characteristic differences between East and West Germany. It is a standard static two-sided matching model that matches workers to jobs (see e.g. Roth and Sotomayor, 1990, for an exposition of a similar model). The non-standard spatial component of the model arises through the spatial allocation of jobs and workers, and through the parameterization of the cost of commuting.

3.1 Assumptions

Three strong assumptions of the model are the absence of migration, the fixed number of jobs per county, and exogenous wage setting. We want to discuss these modeling choices in some detail.

The model abstracts from migration, implicitly assuming that migration costs are prohibitively high. Massive migration from the East to the West took place in the early 1990s. Yet, since then migration flows have been relatively small. It is well established that unobserved migration costs seem to be high in Germany, given that in general we do not observe significant migration flows in response to economic conditions (e.g. Schündeln, 2005, and Decressin, 1994). Hunt (2006) documents that East-West migrants are on average better educated than stayers. One should keep in mind that the assumption of no self-selected migration by skills biases us towards finding lower worker characteristics in the East than in the West. Section 6.2 shows results from a sensitivity analysis that allows for random migration prior to 1998.

We do not model job creation endogenously, but calibrate the number of jobs in each county. Since we want to analyze whether unfavorable job characteristics or low human capital in the East cause the low labor productivity, we remain agnostic about location

the treatment of Berlin.

[15] The data on plant openings were aggregated by Michael Fritsch and are available at the webpage http://www.wiwi.uni-jena.de/uiw/. In these data sets, we treat Hannover continually as one county. In the data on investment and plant openings, which go back before 1998, we also treat Wartburgkreis/Eisenach as one county, since it was only split in 1998.

decisions of firms, and simply take them as given. The job characteristics in our model could capture among others capital, government subsidies, and spill-over effects between firms, and modeling job creation further would require us to take up a stance on which of these factors is especially important.

Wages in the model are exogenous and homogeneous within East and West, but potentially differ between East and West. The assumption of an exogenous wage seems appropriate given the high rate of collective bargaining coverage in Germany. This is especially true for East Germany, where the trade unions played a large role in wage determination after reunification, partly due to the political fear of a large East-West migration (Snower and Merkl, 2006).[16] Kohaus and Schnabel (2003) report that 85 percent of employees in the West and 80 percent of employees in the East were covered directly or indirectly by collective bargaining agreements in 2000.[17]

3.2 Two-sided matching model

Labor productivity depends on workers' skills s_i and counties' job characteristics I_j, where subscript i indexes an individual, and subscript j a county. Skill and job characteristic distributions are the same for all counties in the East and all counties in the West, but they potentially differ between East and West. Specifically, we assume that individual skill levels s_i are independent and normally distributed with mean S_E in East, S_W in West, and the same variance σ_S^2. We assume that the distribution of skills is identical in East and West, since there are no significant differences in the standard deviations of years of schooling between East and West, whether defined by current residence as in Table 18, or by residence before reunification.[18] Counties' job characteristics I_j are constant, and equal to I_E in the former East and I_W in the former West. Evidence for the assumptions of identical mean skills and job characteristics within the East and within the West is provided in Section 7. We indicate as w_j the wage paid in the county where job j is allocated, and as w_h the wage paid in the home county of worker i.

The net pay-off for a filled job is equal to the product generated by labor minus the wage. The product pl generated by person i in a job in county j is a function of worker and job characteristics. We assume the following functional form:

$$pl_{ij} = pl(s_i, I_j) = s_i * I_j.$$

[16] Snower and Merkl (2006) also show that, while the role of unions later declined, their legacy still persists.

[17] According ot he OECD (1994), 90 percent of employees were covered by collective bargaining agreements in West Germany in 1990.

[18] While we argue that years of formal education are not a perfect measure of human capital, they are the best available one. Section 6.1 shows results from a sensitivity analysis in which we assume a lower variance in the East than in the West.

The net pay-off J_{ij} of a job in county j filled by worker i then amounts to

$$J_{ij} = s_i * I_j - w_j$$

while an unfilled job generates a net pay-off of zero, $J_j = 0$. Firms in county j will not be willing to employ individual i if $pl_{ij} < w_j$.

Commuting is possible but costly in the model. The cost of commuting of person i from home county h to county j is a function of the individual distaste of commuting θ_i and the pairwise distance between counties h and j, d_{hj}. We assume $\theta_i \sim U[1,2]$. The specific functional form of the cost of commuting function $c_{i,hj} = c(\theta_i, d_{hj})$ is given in Section 3.3.

The utility W_{ij} for worker i being matched with job j is equal to

$$W_{ij} = w_j - c(\theta_i, d_{hj})$$

while the utility of unemployment amounts to

$$W_i = \lambda w_h.$$

where λ is the unemployment replacement ratio that applies to the wage in the home county.[19] Therefore, an individual is willing to commute if

$$c_{i,hj} < w_j - \lambda w_h.$$

Firms maximize their net pay-off and therefore prefer a higher skilled over a lower skilled worker. Workers maximize their utility and therefore prefer a job in a nearby county to one further away if both jobs pay the same wage. The solution algorithm to solve the model numerically is described in Appendix B.

Note that in this model a qualified individual is not guaranteed to find work in her home county. It might be that either there are not enough jobs available for all qualified individuals living there, or that there are too many higher skilled workers in neighboring counties that would like to commute into the home county. This can generate commuting within the West and within the East. In addition, under the assumptions that $I_E < I_W$ and $w_E = w_W$, the model will result in commuting from the East to the West across the former border. This commuting occurs because some relatively high skilled individuals in the East cannot find a job there since their product of labor is lower than the wage as a result of the unfavorable job characteristics. Yet, these individuals are skilled enough to find a job in the West, where the job characteristics are better. As a consequence, we also see more commuting in the westward direction within the East and within the West. The westward commuting within the West occurs because more skilled eastern workers fill western jobs,

[19] The implicit assumption is that the unemployed person was previously employed in the home county.

and less skilled western job seekers have to find a job further into the West. The westward commuting within the East occurs because the westward commuting of eastern workers close to the border opens vacancies there for eastern workers living further into the East.

The model predicts that, within every county, the least skilled individuals are unemployed, and the most skilled individuals work at home. Thus, relative to stayers, commuters are less skilled.[20] Evidence for the validity of these predictions can be found in the analysis of microdata on East German migrants and commuters by Hunt (2006). Hunt (2006) finds that East German commuters are not higher educated than stayers. Moreover, thirty percent of those beginning to commute experienced a layoff in the previous year, which she interprets as pointing towards a comparatively low skill level of commuters. Last, Hunt (2006) finds that living in a county directly bordering the West raises the probability of commuting to the West threefold. Thus, her results are in line with the predictions of our model.

3.3 Parameterization and Calibration

In the baseline analysis, we assume that the wage is equal in East and West. The nominal East-West ratio of wages shown in Figure 2 is smaller than one. However, since the tax system is progressive, the after-tax East-West wage ratio is larger.[21] Section 6.4 shows results from a robustness check in which the wage in the East is assumed to be lower than in the West. We set the wage equal to $w = 1$, the infrastructure in the West equal to $I_W = 1$, and the variance of the skill distribution equal to $\sigma_S^2 = 1$. We discuss the normalizations of w and I_W in Section 4.2, and estimate rather than calibrate the variance of the skill distribution σ_S^2 in Section 6.1.

The unemployment replacement ratio is set to $\lambda = 0.5$, since the German unemployment insurance system pays around 50 percent of the last income.[22] The total number of available jobs per county is equal to the number of people employed in each county in 2001, plus three times the number of vacancies posted at the employment agency for the respective county, since the IAB estimates that roughly a third of all vacancies are posted that way. The total number of people in the labor force per county is set equal to the labor force in each county, i.e. people living in each county who either work or are registered as unemployed. Figure 19 in Appendix C shows the difference between labor force and jobs in any county divided

[20] Note that, under the alternative assumption $w_E < w_W$, some East Germans who are skilled enough to be offered a job in their home county still prefer a job in the West due to the higher wages, raising the average skill level of East-West commuters somewhat (see Section 6.4).

[21] Moreover, the price level in the East is still smaller than in the West, reducing the real wage difference. Yet, commuters who primarily incur expenses in the county of origin might be more concerned about the nominal than the real wage difference.

[22] The replacement ratio is even higher for the first months (or years) of unemployment, where the length of the period during which the higher replacement ratio is received depends on the length of the employment history.

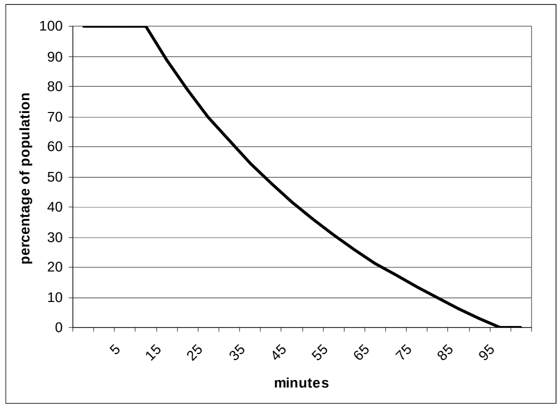

Figure 4: Percentage of population willing to commute a certain number of minutes (one-way)

by the labor force in that county. There is no spatial trend within the East or within the West around the border due to the calibration of jobs and labor force participants, while clearly jobs are more scarce in the East.

The distance between two counties is measured as the driving time between the closest points on a road to the centroids of the most populated *Gemeinden* of every county.[23] All interstates (*Autobahnen*) and larger roads (*Bundesstrassen*) are taken into account in this calculation. We assume that the average driving speed on an interstate is 100 km/h, and on the other roads 60 km/h.[24] With this measure of distance, we calibrate the cost of commuting to take the following form

$$c(\theta_i, d_{hj}) = 0.25\theta_i \left[1 + \frac{d_{hj} - d_{\min}}{d_{\max} - d_{\min}}\right]$$

where $d_{\min}$ corresponds to the minimum one-way driving time everyone is willing to commute, and $d_{\max}$ to the maximum driving time beyond which nobody is willing to commute.

We calibrate $d_{\min} = 15$ minutes and $d_{\max} = 100$ minutes based on the reported willingness to commute from two German surveys. One of these surveys (McKinsey et al., 2005) asks whether a respondent would be willing to commute up to 2 hours per day (i.e. two-way), and 31% of the respondents answer positively. Note that, interestingly, unemployed people do not exhibit a higher willingness to commute in that survey than employed people. In the other survey, conducted by the internet portal meinestadt.de in 2005, the mean one-way distance individuals are willing to commute corresponds to 41 km. 75% of respondents are willing to commute up to 20 km, 50% up to 30 km, 25% up to 50 km, and

[23] There are between 6 and 235 *Gemeinden* in a county (*Kreis*).

[24] Note that the average speed is smaller than the legal speed limit.

10% up to 70 km.[25] Figure 4 shows the percentage of the population willing to commute a certain amount of time under our calibration, and it matches the numbers from the surveys very well.

4 Identification and Estimation

We estimate the model using the method of simulated moments. The variables of interest are S_W, S_E, and I_E, with I_W given. We define the two cut-off skill levels $\widetilde{S}_E$ and $\widetilde{S}_W$ as the skill levels that satisfy $\widetilde{S}_E \equiv \frac{w}{I_E}$ and $\widetilde{S}_W \equiv \frac{w}{I_W}$. Note that anyone with skills below these cut-off skill levels is not qualified to work in East or West, respectively. The parameters to be estimated are the mean skill in the West S_W, the difference in the cut-off skill levels $\widetilde{S}_E - \widetilde{S}_W$, and the difference in mean skills $S_W - S_E$. Thus, the parameter vector β comprises $\beta = \left\{S_W, \widetilde{S}_E - \widetilde{S}_W, S_W - S_E\right\}$.[26] This parameter vector implicitly defines the three underlying variables of interest. We choose these specific parameters since they are largely immune to the normalizations, as discussed in Section 4.2.

4.1 Identification

The model is identified through the regional behavior of the unemployment rate, and especially the behavior of the unemployment rate in the border area.

Given I_W, w, and σ_S^2, the average unemployment rate in the West pins down S_W. In fact, if there were no East-West commuting, and if we would treat the West as one labor market area with unemployment rate UR_W, the mean West skills S_W could be derived analytically. Let $f_W(s)$ be the probability distribution function associated with mean skills in the West S_W and variance σ_S^2, then S_W would be implicitly determined by the condition $P\left(s_i < \widetilde{S}_W\right) = \int_{-\infty}^{\widetilde{S}_W} f_W(s)\, ds = UR_W$.

Any increase in the differences in skills or differences in job characteristics between East and West leads to an increase in the difference of the mean unemployment rates, and thus to an increase in the average East unemployment rate.[27] However, an increase in the skill difference $S_W - S_E$ leads to a *sharper* increase in unemployment rates across the border since less commuting takes place, while an increase in the difference of the cut-off skill levels $\widetilde{S}_E - \widetilde{S}_W$ (which implies an increase in the difference of job characteristics) leads to a *flatter* increase through more commuting. Thus, while an increase in any of these differences leads to a higher average unemployment rate in the East, the effect on the slope

[25] This survey question was answered by 10,006 respondents. The survey by McKinsey et al. has a sample size of 510,000 individuals.

[26] Defined this way, these differences are positive if in fact $S_W > S_E$ and $I_W > I_E$.

[27] For expositional simplicity, we assume here that the East does not look more favorable in either skills or job characteristics, but the logic holds true if this is not the case.

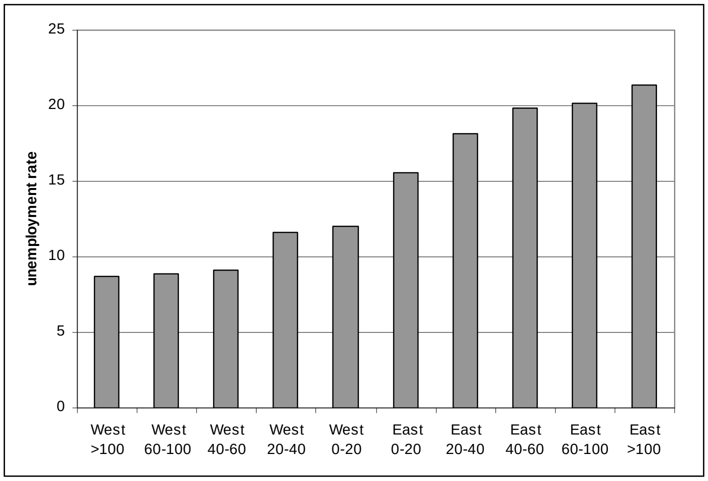

Figure 5: Average unemployment rates of different regions, constructed according to driving time to former border (in minutes).

of the unemployment rate across the border goes in different directions, and therefore both differences are identified.[28]

The variation in the unemployment rate in the model comes from the spatial position of the counties, and the calibrated number of jobs and number of people in the labor force. Within the East and within the West, the model allows for no further variation, e.g. in the form of rural and urban areas, or to capture the general North-South trend in the unemployment rate.[29] It therefore underpredicts the variance of the unemployment rate, especially in the West. We choose to abstract from modelling these additional features, and instead assume that they are orthogonal to the model. The moments to be matched are then regional unemployment rates, with the underlying assumption that these additional features average out within every region.

Given the identification, we choose to approximate the slope of the unemployment rate along the border through a step function, and to match the average unemployment rates of ten regions, putting special emphasis on regions close to the border. For East and West separately, we construct the average unemployment rate of all counties within 20 minutes driving time to the border, those with a driving time to the border between 20 and 40 minutes, between 40 and 60 minutes, between 60 and 100 minutes, and all counties with a driving time to the border of more than 100 minutes.[30] Figure 5 shows the average

[28] I.e. the average unemployment rate in the East could be matched by a continuum of combinations of $S_W - S_E$ and $\widetilde{S}_E - \widetilde{S}_W$, with both differences being negatively correlated, but each of these combinations would predict a different slope of the unemployment rate across the former border.

[29] Note that the model captures part of the decreasing North-South trend in unemployment rates within the West, since more northern counties in the West are affected by East commuters than southern counties.

[30] Since there is not much variation in the average unemployment rates further than 100 minutes away

unemployment rates of these regions; they are monotonically increasing as one moves from West to East.

4.2 Normalizations

Why do we choose to estimate $\widetilde{S}_E - \widetilde{S}_W$ and $S_W - S_E$, rather than e.g. the ratios $\frac{I_E}{I_W}$ and $\frac{S_E}{S_W}$, or directly S_E and I_E? Note that they all are equivalent transformations, and thus in principle the choice does not matter. The reason why we pick the differences $\widetilde{S}_E - \widetilde{S}_W$ and $S_W - S_E$ is that they are immune to the chosen normalizations, namely to the normalizations on I_W and w.

To see why this is the case, assume that we have estimated the parameters S_W^*, $\left(\widetilde{S}_E - \widetilde{S}_W\right)^*$, and $(S_W - S_E)^*$ given the fixed parameters I_W^* and w^*. Now consider a change in the parameterization of either the wage to w^{**} and/or of the West job characteristics to I_W^{**}, resulting in a change of the West cut-off skill level from $\widetilde{S}_W^*$ to $\widetilde{S}_W^{**}$. In order to obtain exactly the same predicted unemployment rates, we have to shift both the East and West skill distributions and the cut-off skill level in the East by exactly the same amount, i.e. by $\widetilde{S}_W^{**} - \widetilde{S}_W^*$. As a consequence, the estimates of $\widetilde{S}_E - \widetilde{S}_W$ and $S_W - S_E$ remain unchanged, and only the estimate of S_W changes to $S_W^{**} = S_W^* + (\widetilde{S}_W^{**} - \widetilde{S}_W^*)$. Thus, the estimates of interest, as well as their standard errors, are unaffected by the assumptions on I_W and w.

4.3 Method of Simulated Moments

Let $UR^t(\beta)$ be the average unemployment rate of region t, and let UR_j^t be the unemployment rate of county j in region t. Moreover, let $\beta_o = \left\{S_{W_0}, \left(\widetilde{S}_E - \widetilde{S}_W\right)_0, (S_W - S_E)_0\right\}$ be the true parameter vector. For every region t, the following moment condition holds

$$E\left(M^t(\beta_0)\right) = E\left(UR_j^t - UR^t(\beta_o)\right) = 0$$

We use the method of simulated moments (Pakes and Pollard, 1989) to find the parameter estimates that minimize

$$\min_{\beta} \widehat{M}(\beta)' W \widehat{M}(\beta)$$

where $\widehat{M}(\beta)$ is a column vector of size ten, and each element of $\widehat{M}$ equals the empirical counterpart $\widehat{M}^t = \frac{1}{N^t}\sum_{j\epsilon t}\left(UR_j^t - \widehat{UR}_S^t(\beta)\right)$ of the above stated moment condition. N^t is the number of counties in region t, and $\widehat{UR}_S^t(\beta)$ is the average simulated unemployment rate in region t, given the parameter vector β.

from the border, and since the cost function is specified such that noone is willing to commute more than 100 minutes, we choose not to break down the region beyond 100 minutes from the border into further subregions.

We apply a two-step procedure. In the first step, which provides consistent estimates of the parameter vector, the weight matrix is equal to the identity matrix, $W = I$. The variance of the moment estimates is defined as $\Omega_M = E\left(M(\beta)\,M(\beta)'\right)$. In the second step, we use the inverse of an estimate $\widehat{\Omega}_M$ of this matrix as the weight matrix, $W = \widehat{\Omega}_M^{-1}$, reoptimize, and get efficient estimates of the parameter vector.[31] Define derivatives of the moment condition with respect to the parameter vector as $G_\beta = \frac{\partial}{\partial\beta}M(\beta)$. The variance of the parameter estimates in the second step is then equal to $\Omega_\beta = \left(1 + \frac{1}{nS}\right)\left(G'_\beta \Omega_M^{-1} G_\beta\right)$, and an estimate $\widehat{\Omega}_\beta$ of Ω_β is used to calculate standard errors for our estimates of β. nS equals the number of simulations. In the estimate $\widehat{\Omega}_\beta$, Ω_M^{-1} is replaced with the estimate $\widehat{\Omega}_M^{-1}$, and the derivatives are replaced with consistent numerical analogues. Under the regularity conditions stated in Pakes and Pollard (1989), the MSM estimator is consistent and asymptotically normally distributed.

We solve the model using pattern search as a minimization algorithm. While the criterion function of this problem is convex, it is not continuous due to the discretization into counties, necessitating a minimization algorithm that does not use the gradient to search for an optimal point. Note that the criterion function has no local minima, yet exhibits a plateau. Due to the calibrated number of jobs and people in the labor force, the predicted unemployment rates cannot fall below certain levels. Thus, at some point an increase in the worker and job characteristics in East and West leads to no further decline in the predicted unemployment rates. Based on grid searches, we make sure that there is indeed a minimum, and that our minimization algorithm does not stop on a plateau but leads to the global minimum. We divide both the number of jobs and the number of people in the labor force by 100, and use 50 simulations.

5 Results

Table 2 presents the results. Strikingly, the estimated West-East skill difference is negative. Thus, East skills are even higher than West skills. Yet, as the 95% confidence intervals show, this difference is not statistically significant. Thus, either human capital accumulated in the East did not depreciate at reunification, or eight years were enough to accumulate new specific human capital, potentially aided by public policy programs with regard to retraining. Early retirement policies after reunification probably make the picture more favorable for skill differences than it would otherwise have been, since older workers should have accumulated more specific human capital, and were more likely to exit the labor market after reunification. On the other hand, selected migration might have lowered the mean

[31] $\widehat{\Omega}_M$ is a diagonal matrix, where the t-th element equals $\widehat{\Omega^t}_M = \frac{1}{N^t}\sum_{j\epsilon t}\left(UR_j^t - \widehat{UR}_S^t(\beta)\right)^2$.

skills in the East; Hunt (2006) shows evidence that emigrants are on average more skilled than stayers.

	coeff.	95% confidence interval	
S_W	2.4779		
	(0.0995)		
$\widetilde{S}_E - \widetilde{S}_W$	0.7065		
	(0.1816)		
$S_W - S_E$	-0.2315		
	(0.0988)		
S_W	2.4779	[2.2829	2.6729]
implied S_E	2.7094	[2.5157	2.9031]
implied I_E	0.5860	[0.4849	0.7404]

Note: Standard errors are in parentheses

Table 2: Results from baseline calibration

Friedberg (2000) analyzes the return to foreign education of immigrants into Israel and finds that, while it is initially lower than the return to native education, acquiring further human capital following immigration can raise these returns even above the returns of natives. It might be the case that, parallel to her findings, the general good schooling in the East combined with some years of labor market experience in the West increases the skill levels of East Germans above the average levels of West Germans.

In contrast to skills, the East job characteristics amount to $I_E = 0.5860$, and are thus lower than the West job characteristics of $I_W = 1$. This difference is significant at the 1% significance level. Hence, our results indicate that unfavorable job characteristics in the East are the driving force of the low labor productivity there. We want to stress again that "job characteristics" in our model capture anything that has a positive influence on labor productivity, but cannot be directly influenced by the worker (e.g., infrastructure, physical capital, network effects between firms). Clearly, several of these factors could be at play, and could together explain the difference. The large financial subsidy programs encouraging firms to invest in the East somehow seem to have failed to produce the same quality of jobs in the East as in the West. We provide further discussion of the results in the conclusion.

Figure 6 shows the resulting simulated unemployment rates for the counties based on 100 simulations, plotted against the driving time to the border, as well as the actual unemployment rates from the data. Our model matches the slope fairly well, but fails to produce enough variation in the Western counties more than 100 minutes away from the border.[32]

[32] Specifically, note that, as explained in Section 4.1, the estimate of S_W effectively sets a lower bound for the predicted unemployment rate in the Western counties further away from the border. The residuals show some remaining spatial correlation which levels off at 200 kilometers, but they do not have a significant

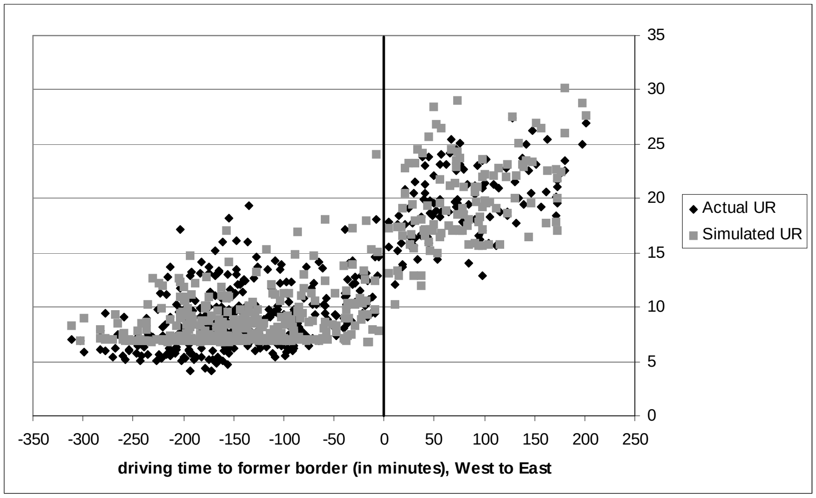

Figure 6: Actual and simulated unemployment rates as a function of driving time to former East-West border

This is not surprising, given that in the model the only heterogeneity of counties within the East or within the West arises through the calibrated number of jobs and number of people in the labor force.

In this analysis, we treat Berlin as part of the East. As a robustness check, we repeat the analysis excluding Berlin and the nine counties directly bordering Berlin. The estimates are very similar, and we are therefore confident that our treatment of Berlin is not crucial for the results. We also estimate the model using a finer definition of regions around the border, namely 15 minutes intervals of driving time to the former border, up to 60 minutes away from the border. Again, the results are qualitatively and quantitatively very similar.[33]

Older worker are typically assumed to have accumulated more specific skills through accumulated experience in an industry or a firm. Therefore, skill depreciation at reunification might have affected older workers more than younger ones. To gain some insights into this hypothesis, we construct unemployment rates for 50 to 64 years old workers, and use these unemployment rates as moments to be matched by the model.[34] This exercise relies on the crucial assumption that the allocation of workers and jobs is the same for the old as for the entire population. Table 3 shows the results. For the older population, the East-West skill difference is almost zero. Compared to the overall population, the skill advantage of East Germans thus disappears, but does not turn into the opposite. This is an indication

East-West trend.

[33] Results are available from the authors upon request.

[34] We have age-specific data on the number of unemployed and employees subject to mandatory insurance contributions on the county level. To construct age-specific unemployment rates, we assume that the age distribution of civil servants and part-time employees matches the one of mandatorily insured employees.

for more skill depreciation for older workers.[35] Note that the mean estimated skills in the West are lower here than in the baseline results, since unemployment rates in the West are higher for the older population. The estimated job characteristics in the East are somewhat more favorable than in the baseline results, but remain significantly less favorable than in the West.

	coeff.	95% confidence interval	
S_W	2.2377		
	(0.0760)		
$\widetilde{S}_E - \widetilde{S}_W$	0.5775		
	(0.1498)		
$S_W - S_E$	-0.0335		
	(0.0191)		
S_W	2.2377	[2.0887	2.3866]
implied S_E	2.2712	[2.2338	2.3086]
implied I_E	0.6339	[0.5344	0.7789]

Note: Standard errors are in parentheses

Table 3: Results from model matched to unemployment rates of older workers

6 Robustness Checks

In this section, we carry out a variety of robustness checks. First, we estimate the variance of the skill distribution in addition to the other three parameters, and additionally carry out a sensitivity analysis in which we set the variance of the skill distribution to a lower level in the East than the one in the West. Second, we present results based on a calibration that allows for migration before 1998. Third, we analyze the sensitivity of the results with regard to the assumed willingness to commute. Fourth, we discuss how the results change if the wage in the East is assumed to be lower than that in the West. Last, we present some evidence how the predicted commuting from the baseline results matches with actual commuting behavior.

6.1 Variance of the Skill Distribution

In the baseline calibration, the variance of the skill distribution is set to $\sigma_S^2 = 1$. In this section, we estimate the variance of the skill distribution in addition to the other three parameters, such that the parameter vector is now $\beta = \left\{\sigma_S^2, S_W, \widetilde{S}_E - \widetilde{S}_W, S_W - S_E\right\}$. Table 4

[35] Self-selection into early retirement, as well as lower migration rates than for the younger population might lead to an overestimation of the skill levels of the older workers as compared to the entire working age population.

shows the results. The point estimate of the variance is 0.89, but it is not significantly different from one. Moreover, the estimates of our variables of interest remain almost unchanged, both in an economic and in a statistical sense.[36]

	coeff.	95% confidence interval	
σ_S^2	0.8932		
	(0.0699)		
S_W	2.3995		
	(0.1353)		
$\widetilde{S}_E - \widetilde{S}_W$	0.6578		
	(0.1497)		
$S_W - S_E$	-0.2092		
	(0.0698)		
σ_S^2	0.8932	[0.7563	1.0301]
S_W	2.3995	[2.1344	2.6647]
implied S_E	2.6087	[2.4718	2.7456]
implied I_E	0.6032	[0.5125	0.7329]

Note: Standard errors are in parentheses

Table 4: Results adding variance of skill distribution as fourth parameter

	coeff.	95% confidence interval	
S_W	2.4778		
	(0.0875)		
$\widetilde{S}_E - \widetilde{S}_W$	0.6776		
	(0.0837)		
$S_W - S_E$	-0.0986		
	(0.0200)		
S_W	2.4778	[2.3062	2.6494]
implied S_E	2.5764	[2.5373	2.6155]
implied I_E	0.5961	[0.5430	0.6607]

Note: Standard errors are in parentheses

Table 5: Results with smaller variance of skill distribution in East than in West

One might also be worried that the variance of the skill distribution is smaller in the East than in the West. While Table 18 shows that the variance of years of formal education is slightly larger in the East than in the West, one might still expect a smaller variance of worker characteristics. If specific human capital mattered a lot and depreciation at reunification was substantial, this could have not only lowered the mean skill in the East

[36] We also ran robustness checks in which we calibrated the variance to be $\sigma_S^2 = 0.8$ or $\sigma_S^2 = 1.2$, respectively. Again, the changes in the estimates are minor.

but also the variance. While our baseline results do not indicate that this was the case, we nevertheless run a robustness check in which we keep the variance of the skill distribution at one in the West, i.e. $\sigma^2_{S,W}= 1$, but lower it to 0.8 in the East, i.e. $\sigma^2_{S,E}= 0.8$. Table 5 shows the results. The results indicate a slightly smaller skill advantage in the East relative to the baseline results. However, none of the results change significantly. Summarizing, we conclude that the results are not very sensitive to assumptions about the variances of the skill distributions.

6.2 Migration

So far, the analysis abstracts from migration and assumes that all individuals currently residing in East Germany have skills drawn from the East distribution, and all individuals currently residing in West Germany have skills drawn from the West distribution. However, migration in the early 1990s between East and West was substantial, although it declined by the mid 1990s. Since we hypothesize that skills in East and West could differ because of the education and job experience accumulated before 1990, this migration could potentially matter for our analysis. In this robustness check, we allow for migration before our sample periods.

	coeff.	95% confidence interval	
S_W	2.4632		
	(0.1094)		
$\widetilde{S}_E-\widetilde{S}_W$	0.6946		
	(0.1337)		
S_W-S_E	-0.2714		
	(0.2440)		
S_W	2.4632	[2.2488	2.6776]
implied S_E	2.7346	[2.2564	3.2129]
implied I_E	0.5904	[0.5111	0.6981]

Note: Standard errors are in parentheses

Table 6: Results allowing for migration before 1998

From the 1998 to 2004 rounds of the German Socio-Economic Panel, we obtain an estimate of the percentage of the population that is originally from East Germany for every county. Now, in the first step of our solution algorithm outlined in Appendix B, we draw skills from the East and West distributions for the population of every county not simply according to whether the county is located in the East or in the West, but according to the estimated percentage of individuals originally from the East and originally from the West.[37]

[37] As an example, for the first county, Flensburg, which is located in the West, we estimate that 94.8

Note that an underlying assumption of this exercise is that migrants are not self-selected. Hunt (2006) provides evidence that migrants are on average better educated than stayers. Thus, our results might still be biased in the direction of underestimating the average skill level of individuals who lived in East Germany before reunification. Table 6 shows the estimated parameters using this additional information. The estimates change only very slightly, and certainly not significantly. This is expected if migrants settled rather uniformly in the respective other part of the country. Section 7.1 provides a further analysis of this issue.

6.3 Cost of Commuting

Since the identification of the model relies on commuting behavior, the assumed cost of commuting is important. Although we calibrate this cost such that the willingness to commute matches evidence from survey data, we analyze how results change if we assume a lower cost of commuting. A lower cost of commuting clearly leads to more commuting; thus, intuitively, in order to still match the slope of the unemployment rate across the border, the estimates have to change in order to decrease commuting again, namely in the direction of lower skills in the East than in the West, with more similar job characteristics in East and West.

	coeff.	95% confidence interval	
S_W	2.3504		
	(0.0466)		
$\widetilde{S}_E - \widetilde{S}_W$	0.4646		
	(0.0352)		
$S_W - S_E$	0.1380		
	(0.0100)		
S_W	2.3504	[2.2590	2.4418]
implied S_E	2.2124	[2.1927	2.2321]
implied I_E	0.6828	[0.6520	0.7166]

Note: Standard errors are in parentheses

Table 7: Results from different calibration of cost of commuting

Table 7 shows the results for an alternative calibration, in which the minimum and maximum amounts of time anyone is willing to commute are doubled from $d_{\min} = 15$ minutes and $d_{\max} = 100$ minutes in the baseline calibration to $d_{\min} = 30$ minutes and $d_{\max} = 200$ minutes. This calibration implies that everyone is willing to commute 30 minutes each

percent of individuals living there are originally from the West. We draw skills from the West distribution for 94.8 percent of the calibrated labor force and skills from the East distribution for the other 5.2 percent.

way to work, and that more than two third of the population are willing to commute one hour each way.[38] When the willingness to commute is basically doubled from the baseline calibration, the estimated mean skill in the East becomes smaller than the mean skill in the West. While this difference is statistically significant, it is small in absolute terms. Moreover, the job characteristics in the East remain significantly less favorable than in the West, and the East-West difference in job characteristics is still much more pronounced than the difference in skills.

6.4 East-West Differences in Wages

Pre-tax East wages are still lower than West wages in nominal terms.[39] To allow for lower wages in the East, we have to modify the model somewhat. First, we change the cost of commuting to ensure that the willingness to commute is independent of the counties of origin and destination.[40] Second, if a job in the West pays a higher wage than a job in the East, then some East Germans who could find a job in the East may prefer to commute further into the West, since the net return to working there (i.e. the wage minus the cost of commuting) may be larger than the net return to working in a closer East county. Thus, individuals do not simply minimize the cost of commuting anymore, but rather maximize the net return to working. This modification increases the willingness to commute from the East to the West.[41]

Table 8 shows results when the wage in the East is set to $w_E = 0.85$, while the wage in the West is kept at $w_W = 1$.[42] The implied skill level in the East is now smaller than in the West, but not significantly so at the 5 percent significance level.[43] The job characteristics

[38] Remember that survey evidence suggests that only one third of the population is willing to commute one hour each way.

[39] There is no significant evidence for a spatial trend in the wage data on the county level. A regression of wages from 1998 to 2003 on a border dummy (that takes on the value one if a county lies within 60 minutes driving time of former border) shows that wages are 2.2 % lower in the West border area than in the rest of the West, but with a p-value of only 0.23. In the East, there is no evidence at all for different wage levels in the border area. Results are available upon request.

[40] This is achieved by assuming that an individual is willing to commute whenever $c_{i,hj} < 0.5$, corresponding to the baseline calibration. Otherwise, we would have to take a stance on which wage, namely from the county of origin or destination, determines the unemployment replacement benefit. Moreover, we do not have any survey evidence on willingness to commute depending on whether the counties of origin and destination lie in East or West.

[41] If the lower wage would be paid to any East German, regardless of the county where the job is located, then the incentives for East Germans to commute would remain unchanged. As a consequence, none of the three estimates from the baseline calibration would change.

[42] The choice of $w_E = 0.85$ is motivated by the fact that income tax reports on the state level show that in 2001, the average tax rate of East Germans is around 5 percentage points higher than the average tax rate of West Germans, such that the after-tax East-West wage difference is smaller than the pre-tax wage difference.

[43] The East-West ratio of mean skills according to the point estimates equals almost exactly the East-West ratio of wages.

	coeff.	95% confidence interval	
S_W	2.5325		
	(0.0781)		
$\widetilde{S}_E - \widetilde{S}_W$	0.1358		
	(0.0899)		
$S_W - S_E$	0.3765		
	(0.1199)		
S_W	2.5325	[2.3793	2.6856]
implied S_E	2.1560	[1.9210	2.3909]
implied I_E	0.7483	[0.6479	0.8857]

Note: Standard errors are in parentheses

Table 8: Results from calibration with lower East wages

remain clearly significantly less favorable in the East than in the West.[44] Thus, allowing for a lower wage in the East reduces the estimated mean skill in the East to a level lower than that in the West, but still identifies the job characteristics as the main driving force of the lower labor productivity in the East.

6.5 Commuting in Model and Data

Commuting data is only available for 71 percent of all employed people, namely employees who are subject to mandatory social insurance contributions. This is the main reason why we match the model to unemployment rates instead of commuting, and has to be kept in mind when comparing these data.[45]

The model underestimates the total amount of cross-county commuting significantly. In the model, 7.5 percent of all employed people commute, while in the data 35.3 percent commute. There are two reasons why the model underestimates commuting. First, in the model, commuting always occurs in only one direction, since there is no random commuting that is not driven by economic incentives. Second, by assumption noone commutes more than 100 minutes one way in the model. Focusing on net commuting in the data, the percentage of commuters falls by more than a half to 16.6 percent, i.e. random commuting accounts for more than half of total commuting.[46] Of all commuters in the data, 88 percent commute less than 100 minutes. Table 9 reports the percentage of all employees commuting

[44] Note that $\widetilde{S}_E - \widetilde{S}_W$ is now defined as $\widetilde{S}_E - \widetilde{S}_W = \frac{w_E}{I_E} - \frac{w_W}{I_W}$. Thus, an estimate close to zero does not indicate equality of job characteristics in East and West, in contrast to the baseline calibration.

[45] It might be reasonable to assume that the omitted 30 percent commute less than the covered 70 percent. Civil servants are in tenured positions and thus have a longer planning horizon when making their residence decision. For part-time workers, commuting is especially costly given the fixed nature of commuting per working day.

[46] Of course, this commuting is only random in the sense of the model, which assumes a homogeneous labor market.

a certain amount of minutes one-way to work in the data. These data are scaled by the number of employees in counties of origin for which the set of other counties within the analyzed driving time is not empty.[47] The percentage of commuters is declining drastically in the data within 100 minutes driving time, which is consistent with the survey evidence that we use to calibrate the cost of commuting.[48] Between 100 and 300 minutes driving time, the percentage of commuters is relatively constant at around 0.6 percent. After 300 minutes, it falls further towards zero. Thus, there is a non-negligible amount of probably weekly commuting in the data that we do not model, since by assumption in the model noone commutes further than 100 minutes. One should also keep in mind that there are tax incentives in favor of reporting a second residence for commuting reasons, which might lead to an overprediction of actual commuting in the data.

commuting time (in minutes)	percentage commuting
0-20	10.64
20-40	12.92
40-60	5.08
60-80	2.15
80-100	1.09
100-120	0.58
120-150	0.69
150-180	0.46
180-240	0.70
240-300	0.60
300-360	0.48
360-420	0.31
420-480	0.11
480-540	0.06
540-600	0.02
over 600	0.01

Table 9: Percentage of commuters relative to all employed people in counties of origin by commuting time, 2002.

To further analyze whether the predicted East-West commuting by the model matches up with the data apart from the level effect of lower commuting in the model, we show two pieces of evidence. First, Figure 7 shows the percentage of East-West commuters relative to all employees in the East counties as a function of the driving time to the former border in data and model. This critical statistic is actually matched fairly well by our model.

[47] For short driving times, the scaling factor is simply the total number of employees in Germany. The scaling procedure only becomes important when we analyze longer driving times, since e.g. not all of the counties have another county that is eight hours driving time away. Through our procedure we take this into account, such that the percentage of commuters does not simply decline with driving time due to the decline in the number of possible commuters.

[48] The percentage is increasing between 0 to 20 minutes and 20 to 40 minutes. Note that only cross-county commuting is reported, and therefore lots of commuting between 0 and 20 minutes remains unreported.

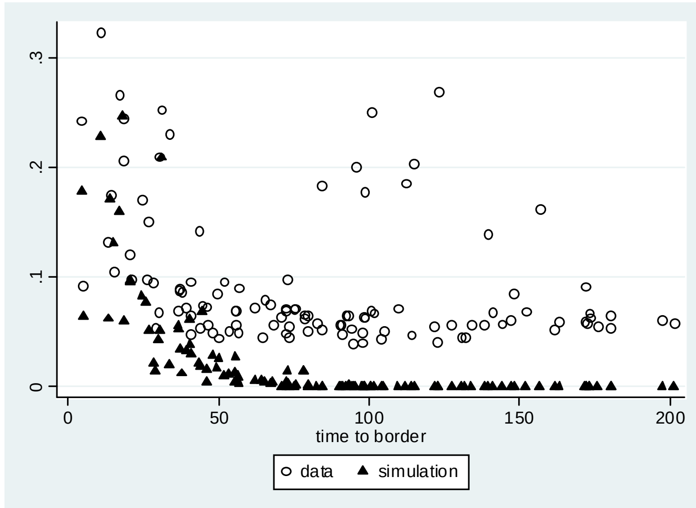

Figure 7: East-West commuters as percentage of employed people in origin county in East in data and simulations.

Naturally, predicted commuting is zero after 100 minutes, but in the counties closest to the border the model matches the observed East-West commuting reasonably well. While the model underpredicts East-West commuting, it nevertheless captures the increase towards the border observed in the data. Figure 20 in Appendix D shows that similarly the data also exhibits a slope towards the border in the West if one analyzes the percentage of East in-commuters relative to the entire labor force working in the host county.

Part of this increase in East-West commuters towards the border is however solely a consequence of the fact that we are focusing on cross-border commuters here. Some increase in cross-border commuting would be expected towards any fictional border. To see whether there is something special about the former East-West border, we run a regression of the percentage of all commuters (i.e. not focusing solely on commuters into the West) relative to employees in the East on driving time to the former border, either linearly or on time group dummies. This variable should capture whether commuting systematically increases towards the border. We control for the size of the county, since smaller counties systematically report higher commuting rates due to the discretization of commuting into counties, exclude Berlin and the surrounding counties, which exhibit above average commuting rates, and run the regression on both the simulated data and the actual data for 2001.[49] Results are reported in Table 10. While clearly the level of predicted commuting is too small compared to the level of actual commuting, the increase in commuting towards the border is quite similar in data and simulations.

[49]Including Berlin and surrounding leads to similar magnitudes, but less significant results, in the regressions on the actual data.

Dependent variable: % commuters	data		simulations	
time to border $(*10^3)$		-0.445**		-0.586***
		(0.183)		(0.131)
0-20 minutes	0.065*		0.096***	
	(0.035)		(0.025)	
20-40 minutes	0.057**		0.063***	
	(0.028)		(0.020)	
40-60 minutes	0.041		0.048***	
	(0.028)		(0.020)	
60-80 minutes	0.074***		0.062***	
	(0.028)		(0.020)	
80-100 minutes	0.071**		0.054**	
	(0.031)		(0.022)	
square km $(*10^3)$	0.014	0.012	0.027***	0.027***
	(0.014)	(0.013)	(0.009)	(0.009)
constant	0.301***	0.382***	0.047***	0.138***
	(0.002)	(0.019)	(0.016)	(0.014)

Note: Standard errors are in parentheses. *** indicates signficance at the 1%, ** at the 5%, and * at 10% significance level. Time dummies equal one if driving time to former border amounts to given minutes.

Table 10: Regressions of percentage commuters on drive time dummies and driving time to border, actual and simulated data.

7 Alternative Hypotheses

The model explains the slope of the unemployment rate across the border through commuting behavior. However, one could potentially imagine other reasons for the gradual increase in the unemployment rates across the former border. The most important alternative hypotheses have to do with the spatial allocation of factors of production. Note especially that the model assumes that every county within the East has the same mean skills and job characteristics, and the same holds true within the West.[50] It could however be possible that either human capital or physical capital are allocated in Germany such that the level and quality is gradually decreasing as one moves from West to East. In that case, the unemployment rate would gradually increase even if all factors of production were only employed in the home county, and thus there would be no commuting. The following two subsections provide evidence on the spatial distribution of human and physical capital within the East and within the West. The third subsection addresses the issue of market access.

7.1 Spatial Distribution of Skills

The model abstracts from migration and assumes the same distribution of skills for every county within the East and within the West. It could however be possible that skill levels are not only higher in West Germany than in the East, but gradually decreasing as one crosses the border. Under the assumption that Eastern skills depreciated somewhat at reunification, for the Eastern side of the border this would mean that either more "West Germans", i.e. individuals who acquired human capital in the West, are settled there than in the rest of the East, or on average higher skilled people are settled there than in the rest of the East. For the Western side of the border, this would mean that either more "East Germans", i.e. individuals who acquired human capital in the GDR, or lower skilled people, settle there than in the rest of the West.

From GSOEP, we get information for every county about the estimated percentage of the population that is originally from West Germany, as described in Section 6.2. Moreover, we derive the highest educational degree of the respondent, analyzing the categories college, vocational training, secondary schooling, and no school degree, and then calculate the percentage of respondents within a county belonging to each educational category. We regress both the East/West composition and the educational attainment on border dummies, as well as on the driving time to the former border.[51] We separately create a West border dummy for counties within 60 minutes driving time to the West of the former border, and

[50] We relaxed this assumption already in the robustness check in Subsection 6.2.

[51] The individual data are aggregated at the county level separately for every year. The standard errors in the regressions are corrected for clustering at the county level.

an East border dummy for counties within 60 minutes driving time to the East.

Dependent variable: % of West Germans	West Germany		East Germany	
West border dummy	-0.045*** (0.017)			
East border dummy			-0.018 (0.017)	
time to border$(*10^3)$		0.200*** (0.077)		0.086 (0.156)
constant	0.953*** (0.005)	0.918*** (0.013)	0.099*** (0.014)	0.085*** (0.011)

Note: Standard errors are in parentheses and are corrected for clustering at the county level. *** indicates significant at the 1% significance level. Border dummy equals one if county lies within 60 minutes driving time of former border. Driving time to border measured as positive number in both East and West.

Table 11: Regressions of percentage of West Germans in population on border dummies and driving time to border, 1998 to 2004

Dependent variable: % college degree	West Germany		East Germany	
West border dummy	-0.012 (0.016)			
East border dummy			-0.012 (0.017)	
time to border$(*10^3)$		0.050 (0.075)		0.138 (0.153)
constant	0.147*** (0.006)	0.139*** (0.012)	0.226*** (0.011)	0.209*** (0.015)

Note: Standard errors are in parentheses and are corrected for clustering at the county level. *** indicates significant at the 1% significance level. Border dummy equals one if county lies within 60 minutes driving time of former border. Driving time to border measured as positive number in both East and West.

Table 12: Regressions of percentage of population with college degree on border dummies and driving time to border, 1998 to 2004

As Table 11 shows, a relatively lower percentage of the population in the Western border counties is from the former West, and the percentage of the population from the former West is generally increasing as one moves away from the border in the West. However, in East Germany the composition of the population does not seem to be influenced by the distance to the border. Moreover, Table 12 shows that the skill composition is not significantly different in the border areas from the rest in neither East nor West. We test this by analyzing the percentage of the population with college degree, but similar results arise if we use total years of formal education as the dependent variable. Summarizing, any evidence that the skill composition differs between counties comes from West Germany alone. However, even in the West the quantities are relatively small: while 95.3% of the population living in West German counties away from the border is from the former West, this percentage declines to 90.8% in the Western border counties.[52]

Dependent variable: labor force participation rate	West Germany		East Germany	
West border dummy	1.305*** (0.413)			
East border dummy			0.601 (0.387)	
time to border $(*10^3)$		-0.010*** (0.003)		-0.006 (0.004)
constant	65.2*** (0.2)	66.8*** (0.4)	68.3*** (0.3)	39.0*** (0.4)

Note: Standard errors are in parentheses and are corrected for clustering at the county level. *** indicates significant at the 1% significance level. Border dummy equals one if county lies within 60 minutes driving time of former border. Driving time to border measured as positive number in both East and West.

Table 13: Regressions of labor force participation rates on border dummies and driving time to border, 1998 to 2004

We also analyze whether labor force participation rates differ systematically across space, which could indicate that all that is differing across counties is how people assign themselves as being either unemployed or out of the labor force . Especially, if the labor force participation rates were to increase systematically across the border from West to East, this might explain why unemployment rates also increase. [53] Indeed, the mean labor force participation rate across counties amounts to 65.4 percent in the West, and 68.5 percent in the East. Table 13 shows the results of a regression of the county level labor force participation rates on driving time to the border. In West Germany, the labor force participation rate is significantly higher in the border counties. The counties within 60 minutes driving time to

[52] If we weigh counties by the number of individual observations used to construct the county aggregates, such that counties for which aggregates are estimated with higher precision obtain a larger weight, results are only slightly different. Most importantly, they indicate that the percentage of the population originally from the West is slightly lower in the East border region than in the rest of the East, as is the percentage of individuals with college degree. Both results are significant at the 10% significance level. Thus, if anything, individuals living close to the border in the East seem to be less skilled than individuals living in the rest of the East. Results are available upon request.

[53] This hypothesis is likely to be true to some extent since labor force participation rates in the GDR were substantially higher than in the former West Germany, especially among women. Bonin and Euwals (2002) argue that part of the East-West unemployment rate difference can be explained through the differential labor force participation of women.

the former border in the West have a labor force participation rate that is 1.3 percentage points higher than in counties further away from the border, but an unemployment rate that is 2.4 percentage points higher (see Table 1). However, labor force participation rates in the East do not exhibit a significant spatial trend.

7.2 Spatial Distribution of Physical Capital

The model also assumes that job characteristics are homogeneous within the East and the West. One might be worried that public infrastructure investment or public subsidies to firms in the East were targeted towards the border area, thus generating more favorable job characteristics close to the former border, as opposed to further East. Note, however, that public transfers into the East are either generated by the German regional transfer system, which seeks to equalize living conditions across Germany, or specific to East Germany. The former implies that regions with the worst economic conditions receive the largest transfers. Transfers within the latter category do not discriminate geographically within the East. The most important specific investment subsidy program for the East (*Investitionszulagegesetz*) specifies by law that subsidies are to be given to all applicable investments, as long as the investment takes place in the East. In fact, one of the major criticism of the vast West-East transfer programs is that they do not focus on certain regions, but rather work indiscriminately. Some subsidy programs apply only to economically underdeveloped areas.[54] These areas include all Western counties at the former border,[55] some selected areas in the West further away from the border, and the entire East. I.e. these programs do not discriminate against West border regions, as compared to the rest of the West; neither do they favor East border regions, as compared to the East. They rather do the opposite in the West, and apply to the entire East. While it is hard to get data at the county level, the Deutsche Bank (2004) for example reports that total investment subsidies for the East from 1990 to 2004 amounted to 18,400 Euro per person. This amount only varied between the five Eastern states from a minimum of 16,770 Euro in Brandenburg to a maximum of 19,890 Euro in Sachsen-Anhalt.

From the Bundesamt für Bauwesen und Raumordnung (2005), we have data on subsidies at the county level from a fairly extensive list of programs from 1999 to 2003.[56] These subsidies average 2,300 Euros per person in the East over the five year period. Assuming

[54] These are the programs under the heading *Gemeinschaftsaufgabe Verbesserung der regionalen Wirtschaftsstruktur*.

[55] The former border areas (*Zonenrandgebiete*) received special federal subsidies before reunification, and continue to do so to a lesser extent today.

[56] The data report amounts for the entire time period, not annual amounts. The programs are: *ERP Eigenkapitalhilfeprogramm, ERP Existenzgründungsprogramm, KfW Mittelstandsprogramm, ERP Regionalprogramm, ERP Innovationsprogramm, ERP Umweltprogramm, GRW gewerbliche Wirtschaft, GRW Fremdenverkehr, GRW Infrastruktur, KfW Infrastrukturprogramm, KfW Innovationsprogramm, KuM-Förderung, Städtebauförderung.*

that the amounts were roughly constant after reunification, these data thus add up to more than a third of the subsidies reported by the Deutsche Bank (2004). Table 14 presents the results from regressing these data at the county level on border dummies and driving time to the former border. The coefficients on the border dummies indicate that West border counties receive less investment subsidies than the rest of the West, while East border counties receive more than the rest of the East. However, both coefficients are insignificant. Only the coefficients on driving time to border are significant. Thus, these data provide some evidence that subsidies are correlated with driving time to border in a way that indicates that subsidies decrease as one moves from West to East, with a break in levels at the border. However, the effects are significant only further away from the border.

Dependent variable: Investment subsidies in Euro per capita	West Germany		East Germany	
West border dummy	-98.8			
	(88.4)			
East border dummy			186.4	
			(186.1)	
time to border		0.978**		-3.619**
		(0.458)		(1.813)
constant	1395.0***	1242.3***	2213.3***	2586.0***
	(32.8)	(71.8)	(114.8)	(175.5)

Note: Standard errors are in parentheses. *** indicates significant at the 1% significance level, ** at the 5% significance level. Border dummy equals one if county lies within 60 minutes driving time of former border. Driving time to border measured as positive number in both East and West.

Table 14: Regressions of investment subsidies in Euro per capita on border dummies and driving time to border, 1999 to 2003

While data on the physical capital stock at the county level does not exist, we can analyze county level data on industrial investment from 1994 to 2002. Table 15 shows the results of regressing annual investment per employee for the period 1994 to 2002 on border dummies and driving time to border.[57] Investment in the border area in the West was lower than in the rest of the West over this time period, although the coefficient is only significant at the 10% significance level. However, investment in the East is uncorrelated with the distance to the border.[58] Thus, these results lend support to our assumption that job characteristics, proxied by investment, are uniform within the East, but show slight evidence that job characteristics might be deteriorating towards the border in the West. Note, however, that investment over this period is a better proxy for the capital stock in

[57] We have data on five time periods, sometimes covering more than one year, which we annualized.

[58] We also run regressions separately on the five time periods. In the East, coefficients are never significant (except for the constant), and in the West, the coefficients are significant for three out of the five time periods.

the East, where much of the capital stock depreciated at reunification, than in the West, where we do not know the quality and quantity of the capital stock in 1994.

Dependent variable: Investment per employee in 1000 Euro	West Germany		East Germany	
West border dummy	-0.650*			
	(0.335)			
East border dummy			-0.960	
			(1.103)	
time to border $(*10^3)$		3.922**		0.916
		(1.687)		(11.697)
constant	6.910***	6.263***	11.177***	10.750***
	(0.145)	(0.271)	(0.904)	(1.013)

Note: Standard errors are in parentheses and corrected for clustering at the county level. *** indicates significant at the 1% significance level, ** at the 5% significance level, * at the 10% significance level. Border dummy equals one if county lies within 60 minutes driving time of former border. Driving time to border measured as positive number in both East and West.

Table 15: Regressions of industrial investment per employee in 1000 Euro on border dummies and driving time to border, 1994 to 2002

Another piece of, albeit imperfect, evidence regarding the spatial allocation of investment comes from data on plant openings. Table 16 shows the results of regressing the number of plant openings per 1000 persons in the labor force at the county level, 1996 to 2004, on border dummies and directly on driving time to the border.[59] Within East Germany, there is no evidence at all that the number of plant openings per 1000 people in the labor force are correlated with distance to the former border. However, within West Germany the number of plant openings is significantly increasing with distance to the former border, though the effect is rather small. Moreover, the West border dummy is not significant, indicating that the distance effect is more important further away from the border.

Summarizing, the results in Tables 14, 15, and 16 provide no evidence that the quantity of physical capital is significantly correlated with the distance to border in the East.[60] In contrast, there is some evidence that the quantity of physical capital is increasing in the distance to the former border in the West. However, this effect is stronger further away from the border, since the border dummy itself is only significant in one of the three regressions (Table 15), and only at the 10% significance level. This makes it less likely that the positive correlation is in fact a causal one.

[59] Data on the number of people in the labor force are from 2002 and are thus not time varying.

[60] The only exception is the significant estimate on time to border in Table 14, where the coefficient on the East border dummy is still insignificant.

Dependent variable: Plant openings per 1000 people in labor force	West Germany		East Germany	
West border dummy	-0.167			
	(0.121)			
East border dummy			0.009	
			(0.138)	
time to border $(*10^3)$		1.544**		1.696
		(0.635)		(1.712)
constant	3.813***	3.570***	5.012***	4.873***
	(0.047)	(0.099)	(0.088)	(0.142)

Note: Standard errors are in parentheses and are corrected for clustering at the county level. *** indicates significant at the 1% significance level, ** at the 5% significance level. Border dummy equals one if county lies within 60 minutes driving time of former border. Driving time to border measured as positive number in both East and West.

Table 16: Regressions of number of plant openings per person in labor force on border dummies and driving time to border, 1996 to 2004

7.3 Market Access

Redding and Sturm (2008) stress the importance of market access in explaining differences in economic performance. They find that, after separation, West German cities close to the East-West border grew significantly slower than other Western German cities, and argue that this is due to the cut-off of market access after 1945. The market access hypothesis could explain why unemployment rates are increasing from West to East in Germany, since trade barriers are smaller within Germany or between Germany and the EU neighbors on the West than between Germany and the Eastern European countries which only became members of the EU in 2004.[61]

One can get insights into the validity of this hypothesis by analyzing unemployment rates before reunification, when the border between East and West was insurmountable. The market access hypothesis implies that the increase in the unemployment rate in West Germany as one moves towards the border should already have existed and should have been even more pronounced before reunification. While implications of this hypothesis cannot be tested for East Germany, in which unemployment was hidden and officially zero, we can analyze the spatial behavior of the unemployment rate in West Germany *before* reunification. To this end, we use the unemployment rates of the years 1987 and 1988 at the county level.

Table 17 shows the results of a regression of unemployment rates in Western counties on the border dummy and driving time to the border, separately for 1987 to 1988 and 1998

[61] However, one might still think that trade barriers are lowest within Germany, and slightly higher between Germany and its EU-neighbors. That should lead to slightly higher unemployment rates along the Western border as well.

Dependent variable: Unemployment rate	1987 to 1988		1998 to 2004	
border dummy	0.900**		2.422***	
	(0.481)		(0.376)	
time to border		-0.011***		-0.016***
		(0.003)		(0.002)
constant	9.537***	11.205***	8.603***	11.146***
	(0.223)	(0.396)	(0.160)	(0.298)

Note: Standard errors are in parentheses and are corrected for clustering at the county level. *** indicates significant at the 1% significance level, ** at the 5% significance level. Border dummy equals one if county lies within 60 minutes driving time of former border.

Table 17: Regressions of West county unemployment rates on border dummies and driving time to border, 1987 to 1988 and 1998 to 2004, respectively

to 2004. While the border dummy and the distance to border variable both have highly significant coefficients with the expected sign in 1998 to 2004, indicating an increase in the unemployment rate as one moves towards the border, both variables are significant, but significantly smaller in the regressions for 1987 to 1988. Thus, the border area suffered from higher unemployment rates than the rest of West Germany in the time period 1987 to 1988, but much more so for the years 1998 to 2004. This makes it unlikely that market access can explain this phenomenon. Buettner and Rincke (2007) document similar effects of reunification on the West German border regions.

8 Conclusion

Fifteen years after German reunification, the labor productivity in the Eastern part of Germany is still significantly lower than productivity in the West. This paper presents a novel method to investigate whether the low labor productivity in the East is caused by worker or job characteristics. We build a model of commuting and differentiate between both hypotheses by analyzing the behavior of the unemployment rate across the former East-West border. We find that the lower labor productivity in the East can be explained by significantly less favorable job characteristics, but that worker characteristics do not differ significantly between East and West. The point estimates in fact indicate that the average skill level is slightly higher in the East than in the West. While it might be reasonable to assume that human capital depreciated somewhat at reunification, it seems that 8 to 14 years were enough to overcome the differences in human capital. Some people, e.g. Canova and Ravn (2000), conjectured that it would take much longer than this. Our estimate is however in line with the view of the Deutsche Bundesbank (1996), which suggested that the retraining period for the East German workforce would be approximately 12 to 14 years. Smolny and Kirbach (2004) find that wage gains of East-West migrants in the decade after reunification are as large as the East-West wage differential, also suggesting that human capital does not differ systematically between East and West Germans.[62]

The results indicate that reasons outside the individual worker's responsibilities are to blame for the low labor productivity in the East. These could include factors in the influence of a single firm (e.g. investment in physical capital), as well as factors that are in the realm of public policy (e.g. public infrastructure), or that need some form of implicit or explicit cooperation between firms (e.g. production externalities and network effects). Clearly, several of these factors could be at play, and could together explain the large East-West difference of job characteristics.

Yet, some of these factors are unlikely explanations for the differences in job characteristics. Since the estimated skill levels are if anything higher in the East than in the West, it should be very attractive for West German firms to settle in the East if firms were able to create the same job characteristics in the East as in the West. This is especially true in the light of the additional investment subsidies in the East. It must be the case that the less favorable job characteristics in the East are in fact not easily influenced by individual firms. This points towards either public infrastructure or agglomeration effects as the main culprits for the unfavorable job characteristics in the East. Since significant investments into public infrastructure have been undertaken since reunification, externalities of production seem to be the most likely explanation. Production networks that have grown over time in the West cannot be transplanted easily to the East, and these missing networks might be at the core of the low labor productivity (see also Uhlig, 2006).

German Reunification provides a unique case study on the transferability of human capital in periods of structural change. It rendered many East German technologies obsolete, and had dramatic consequences for the East German labor market. In contrast to other periods of structural change, the timing and the affected geographical areas are clearly defined. Our estimates suggest that a significant part of the human capital accumulated in the GDR was transferable. To the extent that general education teaches problem solving skills that can then be applied in vastly different environments, one might not have expected a difference in East and West skills, especially given the slightly higher average number of years of education in the former GDR. To the extent that human capital is mostly specific to a certain technology, an occupation, or even a firm, the depreciation of East Germans' human capital at reunification should have been significant. The results thus indicate that, in periods of rapid structural changes in the economy, workers might be able to carry a

[62] However, Brücker and Trübswetter (2007) document a positive self-selection of migrants, casting some doubt that one can make inferences from migrants to the total population.

significant part of their human capital over to new industries. They also suggest that a high level of formal education might largely insulate workers from the negative effects of structural changes, and might enable them to embrace new technologies quickly.

References

[1] Becker, Gary S. (1964): Human Capital, Chicago: University of Chicago Press.

[2] Beer, Siegfried and Joachim Ragnitz (1997): Betriebsgröße und Arbeitsproduktivität im Ostdeutschen Verarbeitenden Gewerbe, IWH, Wirtschaft im Wandel, 16, 11-13.

[3] Bellmann, Lutz and Martin Brussig (1998): Ausmaß und Ursachen der Produktivitätslücke Ostdeutscher Betriebe im Verarbeitenden Gewerbe, Mitteilungen aus der Arbeitsmarkt- und Berufsforschung, 1998(4), 648-660.

[4] Bonin, Holger and Rob Euwals (2002): Participation Behavior of East German Women after German Unification, William Davidson Institute Working Papers Series 477.

[5] Brücker, Herbert, and Parvarti Trübswetter (2007): Do the Best Go West? An Analysis of the Self-Selection of Employed East-West Migrants in Germany, Empirica, 34(4), 371-396.

[6] Buettner, Thiess, and Johannes Rincke (2007): Labor Market Effects of Economic Integration: The Impact of Re-Unification in German Border Regions, German Economic Review, 8(4), 536-560.

[7] Bundesamt für Bauwesen und Raumordnung (various years): INKAR CD-ROMs 1999, 2002, 2003, 2004, 2005, Bonn/Berlin.

[8] Burda, Michael C. and Jennifer Hunt (2001): From Reunification to Economic Integration: Productivity and the Labor Market in Eastern Germany, Brookings Papers on Economic Activity, 2001(2), 1-71.

[9] Burda, Michael C. and Christoph Schmidt (1997): Getting Behind the East-West Wage Differential: Theory and Evidence, in: Pohl, Rüdiger (ed.): Wandeln oder Weichen - Herausforderungen der wirtschaftlichen Integration für Deutschland, Sonderheft, Wirtschaft im Wandel 3/97.

[10] Canova, Fabio and Morten O. Ravn (2000): The Macroeconomic Effects of German Unification: Real Adjustments and the Welfare State, Review of Economic Dynamics, 3, 423-460.

[11] Chari, V.V. and Hugo Hopenhayn (1991): Vintage Human Capital , Growth, and the Diffusion of New Technology, Journal of Political Economy, 99(6), 1142-1165.

[12] Decressin, Jörg (1994): Internal Migration in West Germany and Implications for East-West Salary Convergence, Weltwirtschaftliches Archiv, 130(2), 231-257.

[13] Deutsche Bank (2004): Perspektiven Ostdeutschlands - 15 Jahre danach, Frankfurt am Main.

[14] Deutsche Bundesbank (1996): The Debate on Public Transfers in the Wake of German Reunification, Monthly Report of Deutsche Bundesbank, 48(10), 17-30.

[15] Dietrich, Vera (1997): Kapitalausstattung und Produktivitätsrückstand, IWH, Wirtschaft im Wandel, 7, 5-9.

[16] Felder, Johannes and Alfred Spielkamp (1998): Innovationsstrategien und Forschungsaktivitäten Ostdeutscher Unternehmen, in: Fritsch, Michael, Frieder Meyer-Krahmer, and Franz Pleschak (eds.): Innovationen in Ostdeutschland - Potentiale und Probleme, Heidelberg: Physica.

[17] Friedberg, Rachel M. (2000): You Can't Take It with You? Immigrant Assimilation and the Portability of Human Capital, Journal of Labor Economics, 18(2), 221-251.

[18] Funke, Michael and Jörg Rahn (2002): How Efficient is the East German Economy?, Economics of Transition, 10(1), 201-223.

[19] Grosser, Dieter (2003): Treuhandanstalt, in: Andersen, Uwe and Wichard Woyke (eds.): Handwörterbuch des Politischen Systems der Bundesrepublik Deutschland, Opladen: Leske+Budrich.

[20] Hunt, Jennifer (2006): Staunching Emigration from Eastern Germany: Age and the Determinants of Migration, Journal of the European Economic Association, 4(5), 1014-1037.

[21] Klodt, Henning (2000): Industrial Policy and the East German Productivity Puzzle, German Economic Review, 1(3), 315-333.

[22] Kohaut, Susanne, and Claus Schnabel (2003): Tarifverträge - nein danke!? Ausmaß und Einflussfaktoren der Tarifbindung west- und ostdeutscher Betriebe, Jahrbücher für Nationalökonomie und Statistik, 223/3, 312-331.

[23] Krueger, Alan B. and Jörn-Steffen Pischke (1995): A Comparison of East and West German Labor Markets Before and After Unification, in: Freeman, Richard and Lawrence

Katz (eds.): Differences and Changes in Wage Structures, Chicago: University of Chicago Press.

[24] Lagos, Ricardo (2000): An Alternative Approach to Search Frictions, Journal of Political Economy, 108(5), 851-873.

[25] Mallok, Jörn (1996): Engpässe in Ostdeutschen Fabriken: Technikausstattung, Technikeinsatz, und Produktivität im Ost-West-Vergleich, Berlin: edition sigma.

[26] McKinsey, stern, ZDF, AOL (2005): Projektbericht Perspektive-Deutschland 2004/05.

[27] Mincer, Jacob (1974): Schooling, Experience, and Earnings, New York: Columbia University Press.

[28] Müller, Gerald, Jacqueline Rothfels, and Anita Wölfl (1998): Determinanten der Produktivitätslücke in Ostdeutschland - Ergebnisse eines Workshops am IWH, Teil II, IWH, Wirtschaft im Wandel, 2, 15-21.

[29] OECD (1994): Employment Outlook 1994, Paris.

[30] Pakes, Ariel and David Pollard (1989): Simulation and the Asymptotics of Optimization Estimators, Econometrica, 57(5), 1027-1057.

[31] Ragnitz, Joachim (2006): Humankapital und Produktivität in Ostdeutschland, mimeo, IWH.

[32] Ragnitz, Joachim, Jacqueline Rothfels, and Anita Wölfl (1998): Determinanten der Produktivitätslücke in Ostdeutschland - Ergebnisse eines Workshops am IWH, Teil I, IWH, Wirtschaft im Wandel, 1, 3-11.

[33] Redding, Stephen, and Daniel M. Sturm (2008): The Costs of Remoteness: Evidence from German Division and Reunification, American Economic Review, forthcoming.

[34] Roth, Alvin E. , and Marilda A. Oliveira Sotomayor (1990): Two-Sided Matching: A Study in Game-Theoretic Modelling and Analysis, Cambridge University Press, Cambridge/New York.

[35] Rothfels, Jacqueline (1997): Die Ostdeutsche Wirtschaftsstruktur und die Produktivitätslücke, IWH, Wirtschaft im Wandel, 13, 15-21.

[36] Schündeln, Matthias (2005): Are Immigrants More Mobile Than Natives? Evidence From Germany, Harvard University.

[37] Shimer, Robert (2007): Mismatch, American Economic Review, forthcoming.

[38] Smolny, Werner and Matthias Kirbach (2004): Wage Differentials between East and West Germany. Is it Related to the Location or to the People?, mimeo.

[39] Snower, Dennis J. and Christian Merkl (2006): The Caring Hand that Cripples: The East German Labor Market after Reunification, American Economic Review Papers & Proceedings, 96(2), 375–382.

[40] Spitz-Oener, Alexandra (2007): Human Capital, Job Tasks and Technology in East Germany after Reunification, National Institute Economic Review, 201(1), 97-106.

[41] Tobin, James (1972): Inflation and Unemployment, American Economic Review, 62 (1/2), 1-18.

[42] Uhlig, Harald (2006): Regional Labor Markets, Network Externalities and Migration: The Case of German Reunification, American Economic Review Papers & Proceedings, 96(2), 383-387.

[43] Violante, Giovanni L. (2002): Technological Acceleration, Skill Transferability, and the Rise of Residual Inequality, Quarterly Journal of Economics, 117(1), 297-338.

[44] Yellen, Janet (2001): Discussion of "From Reunification to Economic Integration: Productivity and the Labor Market in Eastern Germany", Brookings Papers on Economic Activity, 2001(2), 72-92.

Appendix

A Work Force Characteristics in East and West

From GSOEP, we can analyze how the work forces in East and West differ according to observable characteristics. We summarize the observable characteristics of individuals in the labor force who are between 20 and 65 years old, according to their current residence in East or West. Table 18 presents the summary statistics. They show that all observable differences between the work forces in East and West are rather small, except for the residence before 1990 ("east origin").[63] Female labor force participation is slightly higher in the East, as are the years of formal education. Most importantly, 27 percent of the Eastern work force have a college degree, while the corresponding number in the West is only 20 percent.

	West Germany	East Germany
sex (male=1)	.55	.52
east origin (east=1)	.05	.90
age	41.0	41.2
	(10.9)	(11.2)
years of education	13.4	14.3
	(2.7)	(2.8)
highest degree:		
college	.20	.27
vocational training	.66	.67
secondary schooling	.12	.05
Observations	45,844	21,347

Note: Standard errors are in parentheses.

Table 18: Summary statistics of work force characteristics in East and West Germany from GSOEP, 1998 to 2004

B Solution Algorithm for the Model

Given $w_E = w_W = w, I_E, I_W, S_E, S_W, \sigma_S^2$ and a matrix of pairwise distances D between the counties, let N_W be the number of western counties, and N_E the number of eastern counties, and let l_j be the number of individuals in the labor force of county j.

We define two cut-off skill levels $\widetilde{S}_E$ and $\widetilde{S}_W$ as the skill levels that satisfy $\widetilde{S}_E \equiv \frac{w}{I_E}$ and $\widetilde{S}_W \equiv \frac{w}{I_W}$. Let $\widetilde{S}_{\min} \equiv \min\left\{\widetilde{S}_E; \widetilde{S}_W\right\}$. We know that any individuals with skills $s_i < \widetilde{S}_{\min}$ will be unemployed, since her skills are not favorable enough to generate a marginal product

[63] Again, we count West Berlin as belonging to the East. These results are unweighted. When using the survey weights, results are almost unchanged, except for east origin, since East Germans are oversampled in GSOEP. The percentage of work force in the West that is originally from the East is 4.4 percent, while the corresponding number for the East is 80.9 percent, when the weights are taken into account.

of labor larger than the wage, even if the individual is assigned to a job in a county with the more favorable job characteristics.

The algorithm is as follows:

1. Draw $\sum_{j=1}^{N_W} l_j$ independent s_i's in West and $\sum_{j=1}^{N_E} l_j$ independent s_i's in East from the appropriate distributions.

2. Draw $\sum_{j=1}^{N_W} l_j + \sum_{k=1}^{N_E} l_k$ independent θ_i's from Uniform [1,2].

3. Rank individuals from higher to lower skills.

4. For each county, rank other counties from smallest to largest distance.

5. Iterate the following steps, starting with individual with highest skills and ending with last individual with skills $s_i \geq \widetilde{S}_{\min}$:
   Check whether there exists an open job in a county where individual is qualified to work, i.e. $s_i * I_j > w$, starting with the closest county.

   (a) If yes, check whether cost of commuting to the closest county for which this is the case is smaller than $(1 - \lambda) w$.

      i. If yes, individual is assigned a job in this county, and number of jobs is updated.

      ii. If no, individual is unemployed.

   (b) If no, individual is unemployed.

6. Compute UR_j's by summing up the number of individuals with skills $s_i \geq \widetilde{S}_{\min}$ in county j that could not find a job and adding individuals with skills $s_i < \widetilde{S}_{\min}$ in county j, divided by the total number of individuals in county j.

C Calibration of Labor Force and Jobs

Figure 19 shows the the difference between labor force and jobs in any county divided by the labor force in that county. A positive number would correspond to the unemployment rate in the county if anyone would just work in the home county, and a negative number indicates open jobs in the county after every labor force participant has been assigned a job in the home county. There is no spatial trend within the East or within the West around the border due to the calibration of jobs and labor force participants.[64] This is confirmed in a regression of this "calibrated unemployment rate" on East or West border dummies,

[64] As with the unemployment rate, the "calibrated unemployment rate" is higher in the East than in the West.

taking on the value of 1 if the county lies within 60 minutes driving time to the former border, where the estimated coefficients are insignificant. This is also true if the “calibrated unemployment rate” is truncated at zero.

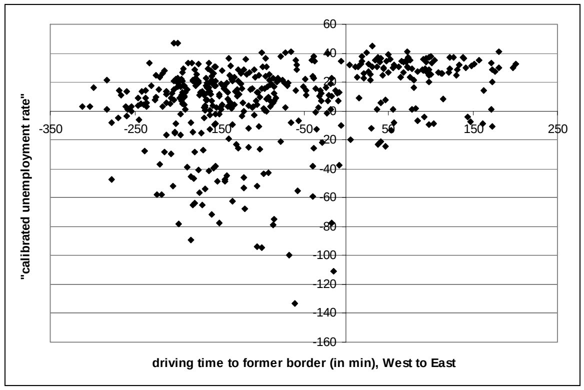

Table 19: County "calibrated unemployment rates" as a function of driving time to border. The "calibrated unemployment rate" is the difference between the labor force and jobs in each county, divided by the labor force.

D Commuting into the West

Figure 20 shows the ratio of commuters from the East to all employees employed in a West German county as a function to the driving time to the former border in the 2002 data and as predicted from the simulations. As in Figure 7, by assumption there are no East commuters working in counties more than 100 minutes away from the border in the model. The model predicts that the percentage of East commuters is higher in border counties, which is also a clear feature in the data.

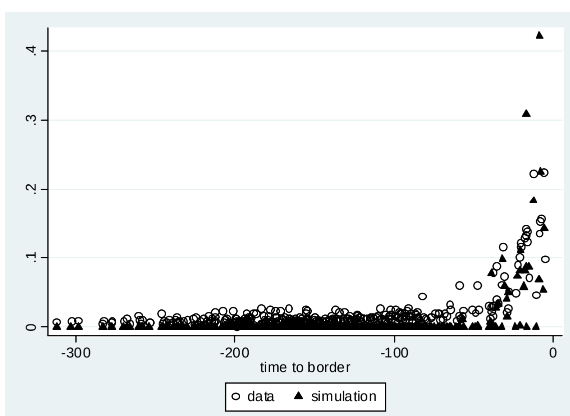

Table 20: East-West commuters as percentage of employed people in destination county in West in data and simulations.