Regional Divergence and Returns to Schooling

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Abstract

Regional economic disparities are large and persistent in EU-8 countries, thanks in part to weak wage and mobility adjustment. In this paper, local returns to education in the Czech Republic are estimated and linked to changing educational composition of local labor force. There is large variation in local educational endowment and relative wages. Districts with more college educated labor force display higher increases in their educational endowment and higher returns to education. This is consistent with models of regional divergence driven by advanced technology adoption or human capital spillovers.

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1 Introduction

The "new economic geography" literature makes the case that in presence of strong increasing returns or local externalities, economic integration is likely to result in the most productive factors flowing to the advanced regions where increasing returns can be realized. In particular, the literature argues that spatial concentration of production factors leads to self-reinforcing spatial divergence (e.g., Fujita, Krugman, and Venables, 1999). Persistent and by some measures growing within-country disparities have therefore become a key concern in the process of European integration, both for the academic and policy audiences.[1]

An important potential source of regional divergence featured in this literature is local human capital concentration. Both skill-capital complementarities and positive human capital externalities can provide an advantage to areas with high skill endowment. Based on the same theoretical arguments, initial differences in the spatial distribution of human capital may be further exacerbated by skill-biased labor migration as skilled labor may be attracted to regions which benefit from high concentration of human capital. This point has been recently made by Giannetti (2003) and Devillanova (2004), who link the empirical work documenting higher mobility of skilled workers with regional divergence models based on human capital externality and skill-capital complementarity arguments, respectively.

In this paper I ask about the "fit" of this strand of theory for the recent experience of a post-communist economy: the Czech Republic.[2] The transition from central planning to market involved dramatic technology and skill upgrading (Commander and Kollo, 2004; Sabirianova, 2004) in large part driven by foreign-direct investment (FDI).[3] The intcreasing international integration

[1] See, e.g., Puga (1999) and Giannetti (2002) for recent theoretical advances, and Canova (2001) and Puga (2002) for a discussion of the European Community's views and regional policies.

[2] See, e.g. Jurajda and Terrell (2003) for a description of the Czech reforms, which started in January of 1991.

[3] The Czech Republic has attracted more FDI (as a percentage of GDP) than any other Central European country.

culminated in the accession into the European Union (EU) of 8 post-communist countries. As I document below using the case of the Czech Republic, the EU-8 economies inherited from communism an extensive spatial variation in skill endowment. Hence, these countries provide a useful case for asking about the importance of local concentration of human capital for the regional outcomes of increasing integration.

I find that more educated areas as of the end of central planning (i) increased their concentration of highly skilled workers during the first transition decade faster than areas starting with a lower skill endowment, and (ii) feature higher skill premia despite their higher level and higher increase in the relative supply of skilled workers. Both findings are consistent with the recent skill-biased-mobility and local-externality theories. I discuss alternative interpretations of the observed pattern including the possibility of skill-biased technological change induced by local concentration of human capital. It appears that the geographical pattern of relative wages is not driven by agglomeration effects stemming from population density changes or by the inherited industrial distribution of local economies, leaving the presence of human capital externalities as a major culprit.

In a subset of the analysis I use the fact that a major part of the variation in local educational endowments is driven by the presence of a public college established under communism. To the extent that the presence of a public college as of the start of reforms is exogenous to subsequent local demand shocks, I can asses the importance of alternative explanations of the observed divergence patterns and test directly for the presence of human capital spillovers. However, this exercise is weakened by the lack of full control for permanent locality-specific characteristics, including physical and cultural amenities. Unlike the geographical pattern of returns to education, the relationship between wage levels and human capital concentration is sensitive to excluding the two main agglomerations of Prague and Brno.

The present analysis also complements two strands of transition economics. First, a large body of empirical research documents the rise in returns to education following the collapse of central

planning, but the relative importance of various underlying causes of the rise in returns, including, e.g., institutional factors or skill-biased technological change, remains unclear.[4] I estimate local-area returns to education within one institutional environment and show that they vary on a scale similar to that present in the before/after transition studies; the within-country evidence on returns then sheds new light on the underlying forces of the general rise in returns.

Second, the present analysis extends the regional-equilibration empirical research from transition countries. The transition from planning to market led to a dramatic increase in regional variation of economic outcomes. While the 2002 unemployment rate in Italy ranged from 3% in the North-eastern regions to 18% in the Mezzogiorno, in the Czech Republic a similar disparity between unemployment rates occurs across districts mere 80 kilometers away[5] and such differences are typical of other transition economies as well (Bornhorst and Commander, 2004). There is now a growing literature suggesting that the persistence of these regional inequalities in transition countries is supported by weak equilibration mechanisms, including an insufficient wage and labor mobility adjustment (see, e.g., Bornhorst and Commander, 2004, Fidrmuc, 2004, or Huber, 2004). The implicit assumption in this line of work is that migration flows should help equilibrate regional imbalances. The observed low territorial mobility of post-communist labor force is then related to the persistence of regional disparities and is itself often blamed on under-developed and regulated housing markets.

In contrast, this paper offers a different explanation for the observed regional divergence – one based on local skill endowments and skill-biased migration. I show that low year-to-year flows mask large 10-year changes in local-area high-skill concentration and, relying on the above-mentioned recent theoretical advances in the "new economic geography" literature, suggest that migration

[4] Two recent studies consider the variation in country-level returns to education in post-communist countries: Fleisher, Sabirianova, and Wang (2004) and Denny, Harmon, and Lydon (2002).

[5] While Prague-West has a registered unemployment rate of 2.3%, the district of Most, about 80 kilometers away, faces a 21% unemployment rate as of 2001. See Section 2 for the definition of Czech districts.

may lead to regional divergence. This results in different policy implications. As a caveat to generalization, it is possible that the importance of local supply of highly skilled labor is particularly high in the Czech Republic, where tertiary educational attainment remains among the lowest in the OECD.[6]

The paper is organized as follows. In the next Section, I illustrate the Czech districts imbalances using data from the 1991 and 2001 census. Section 3 then discusses the economic theory of regional labor market disparities, while Section 4 presents the estimated local private returns to education and wage spillover effects based on a large matched employer-employee data set covering salaried employment in the Czech enterprise sector in 2001. Concluding remarks and policy implications are offered in Section 5.

2 Czech Local Labor Markets

There are 74 districts in my data.[7] Excluding the capital city of Prague, these districts are very small territorial units with average population over 15 years of age of 100 thousand and average labor force of 60 thousand as of 2001. The Prague metropolitan area then has the population and labor force of ten times the respective district average. Figure 1 presents the dramatic 2001 cross-sectional district variation in wages and unemployment.[8]

[6] While total enrollment in Czech colleges doubled during transition, college completion rates decreased. Given the large size of cohorts graduating from secondary schools during the 1990s, tertiary attainment in the Czech population aged 25-34 remains starkly low at about 12% (OECD, 2003).

[7] The Czech Republic's districts were originally established in 1960 and today they correspond to the European Comission's NUTS-4 regional level ("Nomenclature of Statistical Territorial Units"). I pool all Prague's city districts as well as the two suburban districts of Prague East and West into one 'super' district because the city forms one large labor market. Further, one district (Jesenik) is dropped because of time inconsistencies.

[8] The district average wage level is reported by the Czech Statistical Office and based on firm registry wage bills and employment. The registered unemployment rate is calculated off the unemployment registry of the District Labor Offices. Later in the paper, I also use district unemployment rates based on the International Labor Organization's definition; these rates come from the 2001 census.

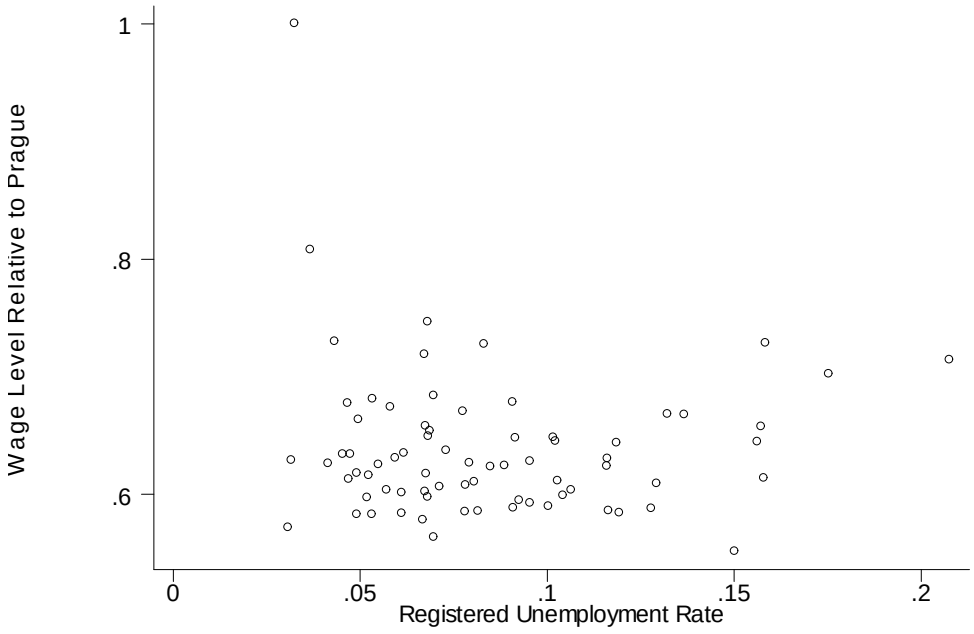

Figure 1: Czech District Wage and Unemployment Disparities, 2001

2.1 Education and Regional Disparities

Next, I present education-district-specific outcomes. This type of evidence is not available in the existing literature on regional disparities in transition. Education is captured either as years of education or in four attainment levels.[9] Although the structure of the Czech educational systems parallels those of other European countries, there is a significant difference in the educational structure of the labor force: While the secondary school completion rate is very high, only a small proportion of Czech workers have completed university. This fact is not surprising given that a major group of secondary-level students attends apprenticeship programs which offer only dismal

[9] The district average years of education are imputed from the district educational attainment by degrees using the typical number of years of educationg required to each type of degree. The district-education-specific unemployment rates are estimated using 2001 region-education-specific labor force participation rates combined with 2001 district-education-specific counts of population and registered unemployment. The Czech Republic consists of 14 regions (NUTS-3 level) and 77 districts (NUTS-4 level).

prospects of continuing on to higher education degrees. Most of the apprenticeship programs do not lead to a school-leaving examinations ("maturita" in Czech), which is a pre-requisite for tertiary education. (These exams approximately correspond to the U.K. General Certificate of Education (GCE) or the German "Abitur" exam.) My preferred categorization of the different education degrees used in the subsequent analysis is therefore into four groups: (i) elementary education, (ii) apprenticeship without GCE, (iii) all types of secondary education with GCE combined, (iv) and college degrees and higher.[10]

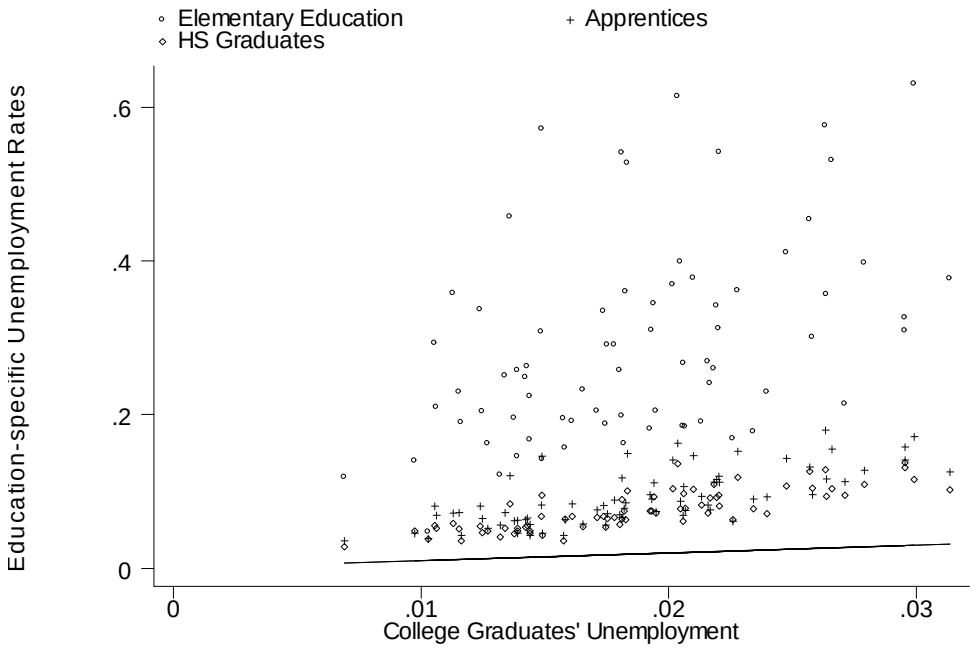

Figure 2: District Unemployment Rates by Education, 2001

Figure 2 illustrates the dramatically higher regional variability of unemployment rates for lower educated workers. The graph plots the unemployment rates for the lower 3 education groups and the

[10]This grouping roughly corresponds to the OECD classification of education levels—the ISCED groups. Category (i) essentially consists of compulsory education and spans ISCED levels 1 and 2. Category (ii) corresponds to ISCED 2 and a small group of workers with ISCED 3C. Category (iii) is identical with ISCED 3A. Finally, the highest category (iv) covers ISCED levels 5 and 6.

45 degree line against the unemployment rates of college graduates. While unemployment rates for the college-educated range from 1 to 3 percent, unemployment rates for high-school graduates range from 3 to 14 percent while unemployment of the workers with only the compulsory (elementary) 8 to 9 years of education goes from 5 to 60 percent.[11]

On the other hand, wages vary more for highly educated workers: Figure 3 presents the variation in education-district-specific residuals from a national log-wage regression controlling for workers' gender, experience and its square and their employer's size (total employment), its square and two-digit industry.[12]

Figure 3: District Relative Wages by Education, 2001

How can these two patterns be reconciled? As many other EU economies, the Czech Republic

[11]These figures are consistent with the national-level unemployment rates by education based on the labor-force survey data. In particular, the ILO unemployment rate of those with only elementary education (ISCED 1 and 2) was 22% in 2001 and Prague, the largest district, had the lowest overall unemployment rate.

[12]See the appendix for the description of the wage data.

has a generous nation-wide level of social support that likely constitutes a welfare trap for low-educated workers (OECD, 2002).[13] Social support provides an effective wage floor such that if there are large differences in worker productivity across districts (or large differences in relative demand for skilled workers), a larger fraction of low-educated low-productivity workers will end up jobless in the less-productive areas. In contrast, in the US, wages of lower educated workers are downward flexible and indeed vary more across locations than wages of highly educated highly mobile workers (Topel, 1986). The EU-US institutional difference would the imply different sources of regional variation in relative wages by skill; I return to this comparison in Section 4.1.

If low-educated workers face similar wage levels across districts because of an effective wage floor set up by a national social support scheme, then local wage adjustment to high unemployment rates of these workers is unlikely. Further, low-educated workers face high unemployment rates in all areas, likely lowering the incentie to migrate. Indeed, educational structure of districts' population explains nearly 50% of the cross-sectional variation in district unemployment rates.[14] Educational structure therefore provides a prime explanation of the persistence in spatial unemployment variation attacked in the transition equilibration literature.

2.2 Educational Divergence

The evidence given above suggests that local education endowments are a major determinant of regional disparities. In this paper, I therefore focus on district disparities in educational attainment

[13] To illustrate the work disincentive effect of these support schemes, consider the Czech social assistance benefits in early 2002, when the average gross monthly wage was over 15 thousand CZK and the pre-tax (net) minimum wage was 5,700 (4,715) CZK. During that time, the minimum living standard for a single individual was 4,100 CZK and a family of two adults and two children aged 11-15 was guaranteed the income of 12 thousand CZK, which is above the after-tax average monthly salary. In some cases, other forms of social support (child and parental allowances) are available on top of the guaranteed minimum subsistence level.

[14] The R-squared in an OLS regression of district 2001 ILO unemployment rate on the shares of each education group in the district population is 0.49.

and ask about their change over time: between 2001 and 1991.[15] Figure 4 plots the college-education shares of district population over 15 and shows that imbalances in educational endowment of districts are significant even outside of the two main cities, Praha (Prague) and Brno (Brno, the capital of Moravia, is the second largest city after Prague).

Furthermore, during the 1990s, there were large changes in district shares of college-educated population: The absolute increase in the share of college-educated population has been fastest in districts which already had a high share of inhabitants with a college diploma.[16] Figure 5 then relates the change in the district years of education, imputed from the district educational-degree composition, to the change in district population shares of college educated.

The change in district educational composition of population over 15 can stem from three main sources: (i) local education production, (ii) skill-biased migration, and (iii) higher mortality of older less-educated cohorts. The sum of these three forces is then biased towards highly educated areas. The last force is unlikely to drive the territorial variability in the change of educational attainment given the stable Czech regional age structure.[17] On the other hand, the presence of a public college in the district jointly with the initial 1991 share of college educated "explain" over half of the variation in the change of the share of college educated population over the first transition decade, suggesting that both local education production (i) and inmigration of skilled workers into areas

[15] Educational structure of the labor force or employment can be estimated for 2001, but is not available for 1991; hence, the time change of local education is investigated using population shares.

[16] District inequality in college shares actually declined during the first transnition decade: As the district average of the share of college educated population grew from 7 to 13% between 1991 and 2001, the coefficient of district variation in this share declined from 39 to 28 percent. However, a more economically meaningful question may be how the dispersion changed relative to the new higher average demand for skilled labor.

[17] In the 2001 census, the share of population aged 65-79 (over 80) across the 14 Czech regions ranged from 10.2 to 11.9 (2.0 to 2.5) percent, with the exception of Prague with 13 (3.2) percent.

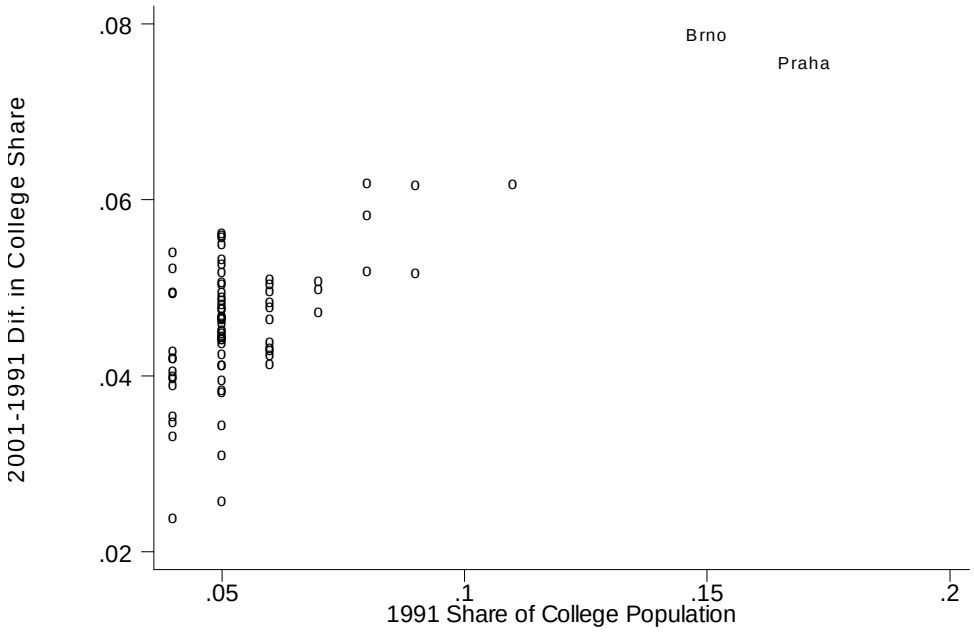

Figure 4: 2001-1991 Change vs. 1991 Level of Share of College-Educated Population

that inherited a highly skilled labor force from communism (ii) are important.[18]

The presence of a public college in 12 out of 74 districts alone explains 52% of the 2001 district variation in the share of college-educated population and it explains 33% of the variation in the change of college-educated population between 2001 and 1991.[19] Students residing near a college may be more likely to graduate from college than those growing up far from a college town. Further, those from rural districts graduating from city colleges may be more likely to stay in the college town. It is important to note that public colleges continue to provide the vast majority of college degrees in the Czech Republic and they remain highly over-subscribed. Their expansion is limited by the low government spending on education and their tuition-free status.

[18] The R-squared of the regression is 52% and both coefficients are statistically significant at the 10% level using robust standard errors.

[19] In contrast, Bound et al. (2004) find only a modest link between the production and stock of baccalaureate degree recipients in the more mobile US population and across much larger territorial units – the US states.

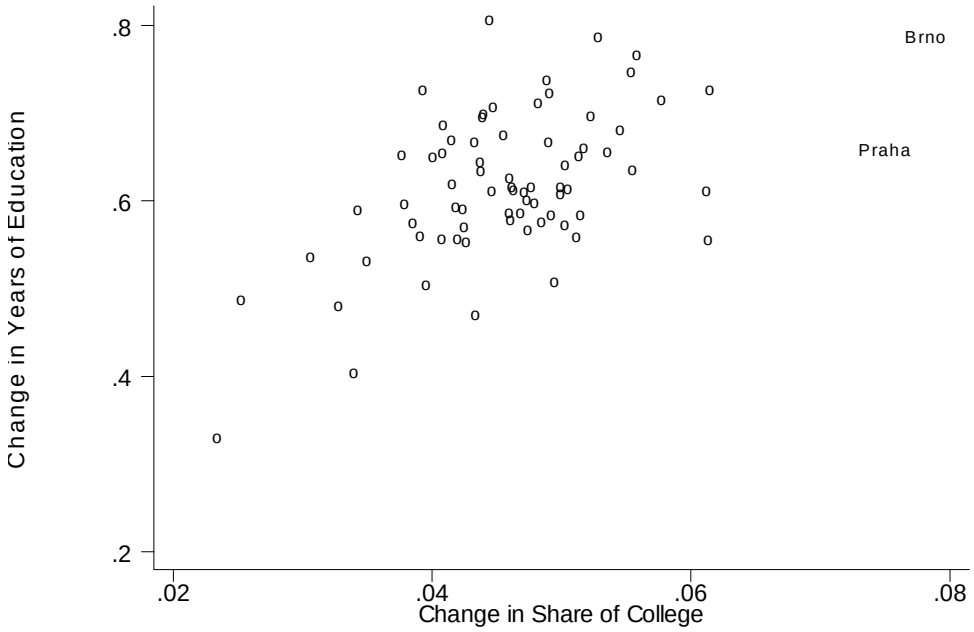

Figure 5: 2001-1991 Change in Educational Attainment of District Population

The link between colleges and average education is weaker: the presence of a college explains 45% of the district variation in average years of education, but does not have predictive power for the change in the imputed years of education. In districts, where average education did not rise thanks to more college, it rose thanks to a higher share of high-school and apprentice diplomas. There is also no link between average years of education in 1991 and the change in years of education between 2001 and 1991. It is also interesting to note that both in terms of population and employment shares college and high-school concentration tends to positively covary across Czech districts and the same is true for the shares of elementary-educated and apprentice-degree holders. In other words, the upper two and bottom two skill groups tend to work together.

Overall, I document extensive end-of-communism variation in local high-skill concentration as well as large changes in educational composition of local populations leading to more concentration

of highly educated workers.[20] Migration studies of cross-district residence change (e.g., Fidrmuc, 2004) find small year-to-year migration flows on the order of 1%, but these small flows mask large medium-to-long-term effective change in district high-skill endowment driven in large part by local education production. The observed pattern is consistent with higher mobility of more educated workers (after or during education) attracted by locations with a higher share of highly educated and may correspond to the regional divergence scenarios modeled in recent economic theory of migration and local returns to skill, which I survey below.

3 Modeling Local Economic Outcomes

How can we interpret the emergence and persistence of the regional imbalances reported above for the Czech Republic and typical of other transition economies? There is now a large empirical literature focusing on regional equilibration in transition. Bornhorst and Commander (2004) study the behavior of labor mobility, employment creation, out-of-labor-force movements and wage adjustment in response to persistent unemployment regional disparities in six transition economies. Their evidence is "rather sobering" as none of the equilibrating mechanisms appears to play a significant role in reducing regional disparities. Similarly, Fidrmuc (2004) who analyzes labor mobility in four transition countries finds that "the efficacy of migration in reducing interregional unemployment and wage differentials is low." There is now also a set of wage-curve studies, which typically find statistically significant, but economically weak wage adjustment to changing unemployment (see, e.g., Münich and Galuščák, 2003, for a study of the Czech Republic).

However, none of the existing studies pays close attention to the regional variation in educational endowment and to its change during transition. As I argue in this section based on recently

[20] The Czech variation in local education endowment is not exceptional in the EU-8 context. In both Prague and Budapest, about a fifth of the population has a college degree, that is about twice the national average. Across the 13 remaining Czech NUTS3 regions, the share of population over 15 with a college diploma varies from 5 to 10 percent, while the corresponding range is 6 to 10 percent across the 19 Hungarian similarly-sized regions.

developed economic theory, this omission may be important. In particular, the above studies consider migration an equilibrating mechanism, which, however, may not be the case. In this section, I discuss two possible interpretations of the observed patterns, one based on models where production functions do not allow for externalities or capital-skill complementarities, the other based on theory which does allow for a role of the local human capital concentration in determining productivity. The two interpretations result in different predictions for the pattern of local skill premia, which is then estimated in the next section based on Mincerian wage regressions.

3.1 Standard Demand-Supply Explanations

A first-hand explanation for the diverging pattern of the local Czech educational endowments is that it corresponds to the uneven distribution of colleges possibly combined with limited territorial mobility of the labor force. In this case of an exogenous increase in the relative supply of educated workers, a simple demand and supply framework[21] (with possible national-level changes in demand by skill due to transition) would predict that relative wages of highly skilled workers should be lower in districts where skilled labor is relatively abundant, at least in the short run.[22]

Alternatively, the change in the concentration of highly educated workers across districts could be a response of mobile labor force to exogenous changes in local demand. Higher relative demand for skilled labor would lead to increases in the relative skill supply and higher relative wages.[23] However, in the Czech Republic, college-degree concentration increases more in districts which had more college-educated labor as of 1991. In order to rationalize a positive association between relative wages and the observed increases in relative supply within a simple demand and supply framework,

[21] See Bound et al. (2004) for a recent exposition of such demand-supply model.

[22] Over the long run, firms adjust labor demand by focusing on technologies intensive in skilled labor in regions relatively abundant in skills. Indeed, with full adjustment in labor demand, exogenous differences in skill supply would lead to no differences in relative wages.

[23] Ultimately, in a labor market with full mobility adjustment, i.e. no migration costs and no local amenities, there would be no relationship between the relative supply and relative wages of skilled workers.

one would have to answer the question of why relative demand for skilled labor increased more in areas initially relatively abundant in skilled labor. It is possible that transition led to an increase in the productivity and employment in industries that use skilled workers more intensively and that these industries were initially located primarily in the highly-educated areas. In the empirical analysis, I therefore control for this possibility by conditioning on the end-of-communism local industrial composition. Alternatively, the higher skill demand could be endogenous to the initial concentration of skilled labor, which is the object of "increasing returns" theory summarized below.

3.2 "Increasing Returns" Explanations

The "new economic geography" literature argues that spatial concentration of production factors leads to self-reinforcing spatial divergence (e.g., Fujita, Krugman, and Venables, 1999). The divergence of skill endowments described in Section 2 could therefore be an endogenous outcome related to local area advantages stemming from initial skill concentration. Recently, these theoretical arguments have also been linked to the empirical evidence on higher mobility of skilled workers.[24]

Giannetti (2003) analyzes an overlapping-generations migration model with skill complementarities and endogenous regional price differentials. Based on the assumed technology, the wage of a worker depends on her own skill level as well as on the average skill level of the region. Human-capital complementarities imply that highly skilled workers benefit more from the productivity increases due to a higher average skill level.[25] If both the average productivity and skill premium are increasing in the average local level of human capital, then skilled workers have a stronger motivation to migrate to the most productive regions, i.e. regions with a high concentration of human capital. Regional price differences then arise in a Balassa-Samuelson fashion from the higher pro-

[24] See, e.g., Greenwood (1997) and Borjas et al. (1992) for evidence on skill-biased mobility from the US and Boeri and McCormick (2001) for research on the EU.

[25] For the underlying theories of human capital externalities, see, e.g., Kremer (1993) and the extensive set of references offered in Moretti (2004). I return to the topi of human-capital spillovers in Section 4.3.

ductivity in the traded goods sector of regions with higher skill level; such higher price level then implies out-migration of less skilled workers. In this way, initial variation in skill endowments and self-selection of skilled migrants give rise to ex-post technology differences and can generate poverty traps for regions starting from less favorable conditions.

The preliminary evidence on the Czech districts presented in Section 2 is consistent with this model in that the rise in the concentration of highly skilled workers has been largest in districts where the concentration of human capital was already the highest. This could correspond to both a higher migration of skilled workers to more productive districts as well as with out-migration of less skilled workers. On the other hand, the empirical link between average schooling level, the key variable in Giannetti's model, and college concentration is weak (Section 2.2). If human-capital spillovers are present,[26] then skill premia should be higher in districts featuring higher average skill level. Further, if the presence of college labor is important for human-capital externalities, then the theory also predicts that Czech districts receiving more college labor during the first transition decade should have higher skill premia. According to Giannetti's 2003 model, these districts should also feature high price level.[27] These predictions are taken up empirically in the next Section.[28]

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[26] In Section 4.3 I attempt to test for the presence of human-capital spillover following Moretti (2004).

[27] This prediction contrasts with that of the migration model of Black et al. (2004). Skilled workers may prefer to live in areas where skill production takes place because of local amenities. Black et al. (2004) analyze worker migration in a model where local price and wage variation arises from differences in local amenities. They consider two types of workers (skilled and unskilled) and assume that wages are equalized for one of the two types of workers across locations. This implies that the price of housing is higher in higher-amenity locations. As long as amenities are "luxury" goods relative to housing, low-educated workers have a lower willingness to pay for the amenity compared to high-educated workers. For less skilled workers to live in a city with higher amenities and higher housing prices, they must be offered a higher wage. Hence, Black et al. (2004), who do not consider the effects of relative skill supply, predict that cities with higher housing prices should have lower returns to education.

[28] An alternative theory of regional divergence is offered by Devillanova (2004) who considers the skill-biased composition of internal migration in presence of capital-skill complementarities in the local production function and imperfect substitution between high- and low-skilled workers. In his model of a two-regional dynamic economy with perfect capital mobility, labor movement across regions is spurred by stochastic shocks to local productivity. Skilled

Finally, there is one more related potential source of a link between local relative skill supply and skill premia: the work of Acemoglu (2003), who analyzes country-level effects of international trade and endogenizes skill-biased technological change to relative skill supplies. While the focus of the model is on the induced skill-biased technological change in the developed economies (technology leaders), the theory also has predictions for the evolution of skill premia in less-developed countries. In the basic version of his model, the Czech Republic, given its large inflow of FDI, would be classified as a technology follower and would be predicted to experience a downward pressure on its skill premium from opening to international trade. However, a possible extension of his basic model (outlined in Section 5.3 of Acemoglu, 2003), involves endogenizing technology adoption in the technology followers to the relative amount of available skill. A tantalizing but informal strategy would be to take this logic to the regional level, where more skill-biased technologies would then be adopted in more skilled regions which would then exhibit greater skill premia.

4 Local Wage Analysis

4.1 Local Returns to Education

In this section I present two types of district-specific education wage premia: the log-wage return to an additional year of education and the log-wage gap between workers with college degrees and those with all types of high-school education (i.e. both with and without the 'maturita' exam, see Section 2). The details of the estimation procedure are given in the Appendix.

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workers migrate to the region with a positive productivity shock, which, thanks to capital-skill complementarities, amplifies the idiosyncratic productivity shocks and increases the average productivity differences between skilled and unskilled workers. In a competitive labor market, the skill wage premium rises in the region which loses skilled labor and the premium can rise even in the region which receives skilled migrants because of the rise in investment motivated by the productivity shock. On the other hand, in the presence of EU-type labor market rigidities, labor mobility increases regional dispersion of unskilled workers' employment. While this model does not have a clear prediction for the pattern of skill premia across sending and receiving regions, except for a positive relationship with capital investment, it highlights the role of migration in aggravating regional inequalities.

The evidence given below on local returns to education is novel in the transition context. It is now well documented that wage differentiation and returns to education rose quickly during transition from central planning to market economy (Svejnar, 1999, Fleisher et al., 2004).[29] However, there are no studies estimating local returns to education in a transition economy. This type of evidence is also relatively new in the context of developed economies. Beeson (1991) and Black et al. (2004) are the only studies that focus solely on estimating local returns to estimation.[30] Black et al. (2004) estimate city-specific college/high-school wage gaps for the US and find these to be large and persistent. In 1990, their estimated log wage gap varies from 0.33 in Seattle to 0.54 in Houston. They also show that U.S. skill premia are lower in cities with higher housing prices (see note n. 27).

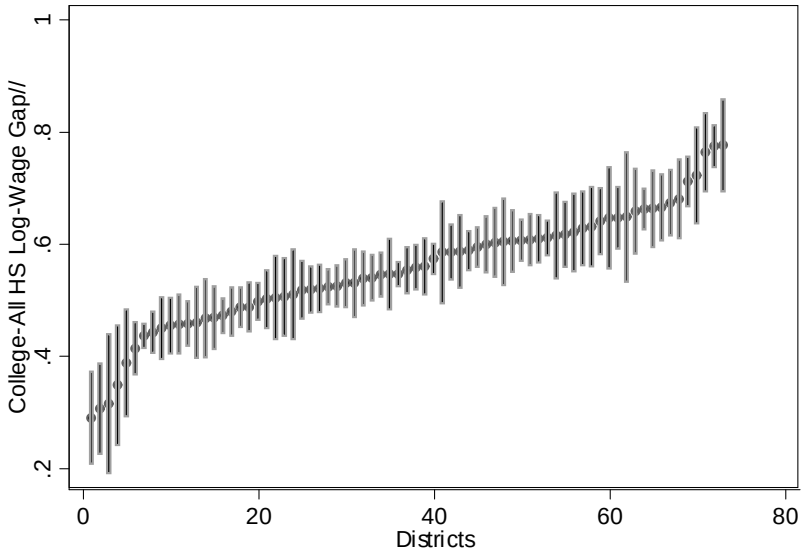

Figure 6: District College/High-School Wage Gaps w/ 95% Confidence Intervals

[29] For evidence on mid- to late-transition returns to education in the Czech Republic, see Filer et al. (1999) or Münich et al. (2005).

[30] Although see Bound and Holzer (2000) or Wheeler (2001) who also consider relative wages by skill at the local level in the U.S.

I find extensive variation in 2001 Czech local returns to education and in local college/high-school wage gaps. District-specific returns to a year of additional education range from 0.03 to 0.11, while the average standard error of these district coefficients is only 0.008.[31] The variance in returns to an additional year of schooling present within one transition country, and therefore unaffected by macroeconomic or institutional variability, is therefore comparable in magnitude to the variation in country-level returns before and after transition (see, e.g., Fleisher et al., 2004). Comparing college-educated employees with high school graduates leads to district log-wage gaps ranging from 0.29 to 0.81, which is a range somewhat wider than that found for the US by Black et al. (2004). Figure 6 sorts and presents these district estimates of the college/high-school gap together with the 95% confidence interval of each estimate. Clearly, the variation in returns is not an artifact of sampling variance.

4.2 Relative Supply and Wages by Skill

To the extent that the observed changes in relative skill supply are exogenous, standart demand-supply theory predicts a negative correlation between Czech skill premia and relative skill supply change. The opposite correlation is predicted by a set of recent theories based on local "increasing returns" to human-capital concentration.[32]

In this section I first present simple correlations between relative skill supply or its change and local relative wages by skill. Next, I estimate conditional correlations of several variables with the local returns to education. The additional co-variates are related to capital investment and

[31] See Münich et al. (2005) for a comparison of Czech returns to education based on years of schooling imputed from highest-degree-attained information to those based on reported years of schooling.

[32] A standard demand/supply approach would relate the change in supply to the change in relative wages. I do not have available a measure of district-specific relative wages in 1991. However, given that under the communist regime, returns to education as well as regional differences in relative wages were small and strictly regimented by the use of a wage grid (Munich et al., 2005), the 2001 wage structure estimated below can be thought of as approximating the bulk of the change in relative wages between 1991 and 2001.

local price level and are motivated in the theoretical models presented in Section 3. In particular, I proxy for capital investment by district FDI stock (following Denny et al., 2002) and for price level by a local housing price index (following Black et al., 2004) and also control for local labor-force participation (following Denny et al., 2000). These additional variables may help differentiate among several underlying structural models. Finally, I also control for the industrial structure as of the end of centrall planning.

I have available two measures of educational endowment (with the corresponding relative wage measure): district years of schooling and share of college labor. The interpretation of the relationship between endowments and returns for these two measures is different: While the district returns to years of schooling are based on a measure of total district human capital, the college/high-school wage gaps not only reflect the concentration of college-educated workers, but also the within-district relative supply by skill.

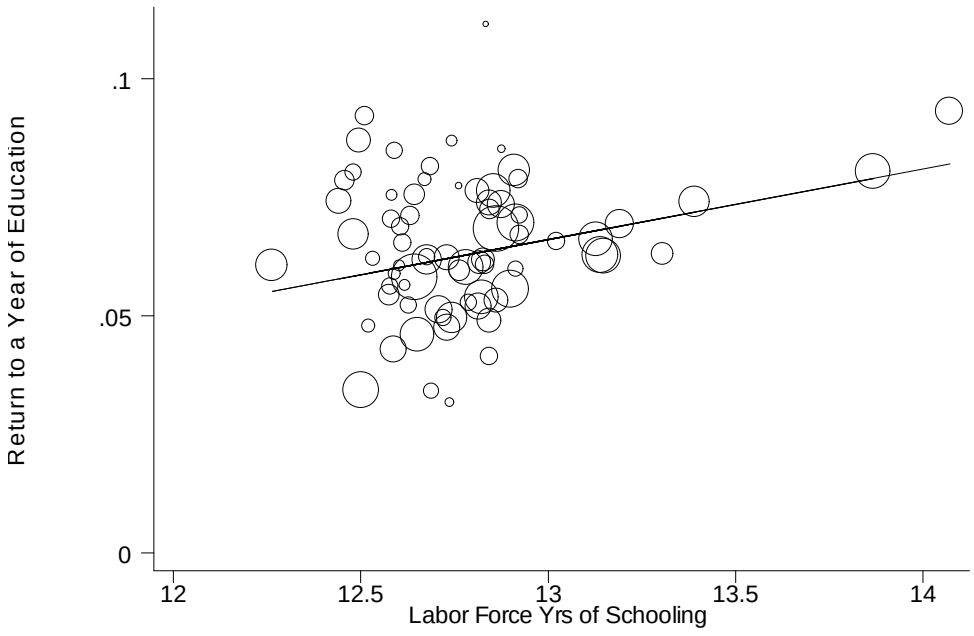

Figure 7: District Returns to Education and Average Education

Figure 7 illustrates graphically the data I work with and plots district specific returns to a year of education against the average education in districts' labor force in 2001.[33] The data are weighted by the inverse of the variance of the estimated returns and a fitted regression line is superimposed. There is a statistically significant positive relationship between the education of districts' labor force and their wage return to education, which is not fully robust to excluding the two most educated and largest cities, as shown in the top left panel of Table 1. Focusing on the variation in district education driven by the presence of a public college set up before the fall of communism, i.e. instrumenting using a college dummy, however, I again obtain a significant positive coefficient.

The present distribution of public colleges, which drives much of the variation in district college concentration, was established under Communism and may therefore be thought of as being exogenous to the skill demand shocks of the new post-communist economy. Most of Czech colleges were established in the 1950s and 1960s and only a small subset was originally related to a local large firm.[34] Nevertheless, in districts where the original impetus for establishing a university was tied to strong manufacturing and to the extent that this manufacturing was important as of 1991, it is likely that overall labor demand dropped during transition, but the effect on relative demand for skilled labor is unclear. When relying on the exogeneity of the spatial distribution of tertiary education production, it is therefore important to control for end-of-communism industrial structure.

Next, the bottom left panel of Table 1 asks if returns to education are higher in districts which

[33] Acording to the 2001 Census, 20% of Czech employed workers commute outside of their district of residence. Ideally, one would empirically model this spatial spillover of skill supply, but such estimation is beyond the scope of this paper.

[34] Except for Prague and Olomouc, where universities were founded by 1348 and 1573, respectively, the other Czech colleges were typically established during the 1950s and 1960s. They often started as a pedagogical faculty (in, e.g., Ústí nad Labem, Hradec Kralové, or České Budějovice) or as engineering faculties tied to local manufacturing or chemical production (in, e.g., Plzeň, Zlín, Pardubice) and they all branched out into other fields by adding faculties over time.

Table 1: District Education and Skill Premia

	(1)	(2)	(3)	(4)	(5)	(6)
	Return to Education			College/HS Wage Gap		
District Education Level	0.015	0.009	0.014	-0.044	-0.109	-0.083
	(0.004)	(0.006)	(0.007)	(0.038)	(0.042)	(0.050)
District Education Change	0.033	0.023		0.065	0.138	0.143
	(0.019)	(0.019)		(0.049)	(0.046)	(0.047)
Prague and Brno	Yes	No	No	Yes	No	No
IV	No	No	Yes	No	No	Yes

Notes: Each estimate comes from a separate regression. The dependent variable is district return to education or college/high-school wage gap. The independent variable is the level of or the change in either district average years of education or the log of the ratio of college degree holders to those with a high school diploma. Robust standard errors in parentheses. The regressions are weighted using the inverse of the variance of the district estimates of skill premia. The instrument used in the IV specifications is the presence of a public college in district.

experienced a larger increase in their average years of education.[35] The estimate in column (1) implies a strong positive relationship between the increase in districts' educational endowment and their returns to schooling; however, this estimate is not statistically significant after excluding the two major cities.

The right panels of Table 1 then replicate the level and change analysis using the relative supply of the college educated as the independent variable and the college/high-school wage gap as the dependent variable. There is a negative cross-sectional relationship in the top right panel, consistent with a relative supply explanation and less than perfect mobility of college educated labor across

[35] Given data limitations, the two measures of educational change used in the bottom panels of Table 1 are based on population educational structure, as opposed to that of the labor force.

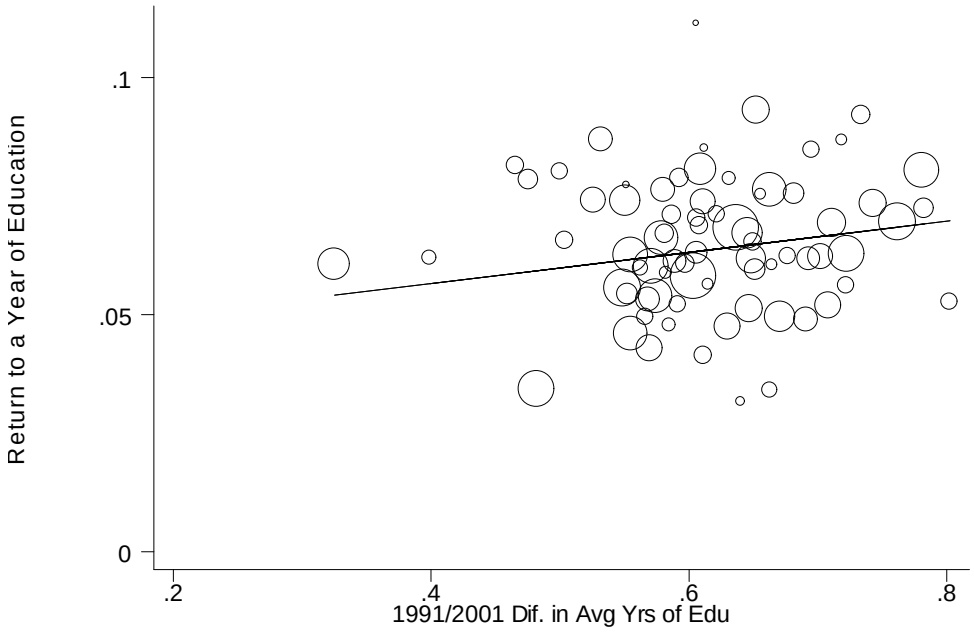

Figure 8: District Return to Education and Change in Average Education

districts.[36] In contrast, the bottom right panel suggests that outside of the main two cities, there is a positive relationship between the increase in the relative supply of college labor and its wage premium.

Controlling for Demand Shocks While district educational composition of population or labor force provides a direct measurement of education supply on the local labor market, it is less clear how to control for local changes in relative demand. It is tempting to approximate demand shocks of transition reallocation by a Katz-Murphy-type man-power demand index based on the locality-specific reflection of country-wide industry-employment changes. Yet, much reallocation in transition occurs within industries (Jurajda and Terrell, 2003) such that it is not clear whether this index would be meaningful. On the other hand, I can control for the more recent demand shock of increasing international integration by conditioning on the 2001 district stock of per capita FDI. The

[36] The estimates in the top right panel are consistent with those reported by Bound et al. (2004) for the US.

Table 2: Employment by Education and Ownership

Share of employment	Apprentices	HS Graduates	College Graduate
Foreign Owned	0.456	0.274	0.109
Private	0.518	0.264	0.078
Co-op	0.617	0.202	0.031
State Owned	0.451	0.354	0.075
Mixed	0.403	0.375	0.127

Czech Republic has attracted more FDI (as a percentage of GDP) than any other Central European country. Table 2, based on the matched employer-employee data used in the wage analysis of this paper, documents that foreign-owned firms indeed use more college educated labor compared to state-owned or locally private owned firms.

Using the district official FDI data, I also confirm that more educated regions are the prime recipients of FDI. Regressing cumulated 2001 district FDI per capita[37] on the 1991 district share of college-educated population over 15 results in a positive and statistically significant coefficient (using robust standard errors) of 0.05 (0.018) with (without) Prague. Excluding the capital Prague and going from the minimum to the maximum 1991 share of college-educated population (i.e. going from 0.04 to 0.15) then corresponds to additional 2 thousand USD FDI per capita – that is about one district standard deviation in FDI per capita. Sabirianova et al. (2004) show that foreign-owned firms are substantially more productive compared to both locally-owned private and state-owned firms.

Extended 'Returns' Regression Analysis To further understand the variation in Czech district returns to education I regress the 2001 returns on the demand-correlated FDI measure as well as two supply controls. The recent economic theory described in Section 3 models the

[37] I use 2001 FDI in millions of USD.

divergence in skill endowments based in part on local initial conditions. Below, I therefore ask (i) if returns to education are larger in districts which had a higher human capital endowment in 1991, the year of the start of post-communist economic reforms, and (ii) how returns relate to the change in district educational attainment between 1991 and 2001, shortly before the EU accession. Finally, guided by the stylized facts from the cross-country literature on international differences in returns to education (e.g., Denny et al., 2001) as well as by the existing work on local returns (Black et al., 2004), I also control for district unemployment rate, population density, and an index of housing prices. Table 3 presents the results of these extended 'returns' district regressions.

Columns (1) and (2) present the estimated coefficients from regressions explaining variation in district return to an additional year of education. Simultaneously controlling for the 1991 average years of schooling of a district population and its change between 2001 and 1999 results in large positive coefficients, even excluding the two main cities. Districts which received more FDI have, ceteris paribus, higher returns to education.[38] Districts with higher unemployment rate and higher price of family houses have a higher return, while, conditional on other covariates, higher density is negatively correlated with the level of district skill premium.

The coefficients of the education supply controls are consistent with the presence of strategic human-capital complementarities à-la Giannetti (2003). The estimates of the FDI parameter are consistent with the demand shocks of international integration being an important determinant of higher returns to education.[39] The unemployment rate coefficient is driven by short-term unemployment (of duration below 12 months), as suggested by an unreported regression conditioning separately on short- and long-term unemployment, and by the unemployment rate of high-school graduates with a school-leaving exam, as suggested by another specification controlling for unem-

[38] In contrast, looking across countries, Denny et al. (2001) find a negative effect of the inflow of FDI as % of GDP on returns to education.

[39] The demand explanation can possibly be behind the positive housing price estimate as well as mainly the successfull mobile highly educated workers purchase family houses.

Table 3: Determinants of District Skill Premia

	(1)	(2)	(3)	(4)
	Returns to Education		College/HS Wage Gap	
1991 Education	0.028	0.029	1.393	1.546
	(0.009)	(0.009)	(0.790)	(1.190)
Change in Education	0.043	0.045	1.714	1.885
	(0.018)	(0.019)	(0.926)	(1.370)
FDI per capita	0.672	0.691	-3.693	-3.943
	(0.433)	(0.407)	(4.974)	(5.039)
Population Density	-0.182	-0.186	-0.782	-0.787
	(0.071)	(0.071)	(0.476)	(0.476)
Unemployment Rate	0.220	0.226	1.192	1.201
	(0.045)	(0.045)	(0.370)	(0.365)
Housing Price	0.039	0.025	0.310	0.327
	(0.019)	(0.028)	(0.125)	(0.222)
Prague and Brno	Yes	No	Yes	No

Notes: See notes to Table 1. The FDI measure is a district stock of USD million. The density rate is the number of inhabitants per square kilometer / 10,000. The house price index is the avg. price of family houses sold during 2000-2002, relative to Prague level.

ployment rates by education group.

Columns (3) and (4) of Table 3 list the estimates from similar regressions using as dependent variable the college/high-school wage gap for each district. Both the 1991 measure of relative college supply (i.e. the log of the ratio of the number of college degree holders to high school graduates) and the change in this measure between 2001 and 1999 have coefficients that are positive and statistically significant at the 10% level in column (3), but become noisier in column (5) after excluding the two main cities. The parameters of other explanatory variables retain their sign from columns (1) and (2), with the exception of the FDI estimate, which is now negative and very imprecise.

Overall, the evidence is consistent with regions with a greater supply of skills adopting (receiving) more skill-biased tehnologies and having greater skill premia. This is in line with an extension of the basic Acemoglu (2003) trade and induced technology model, where technology adoption is endogenized with respect to the local supply of skills.

4.3 Spillover from Education

In this section I provide a further test of the selected theories of regional migration and divergence presented in Section 3 by asking whether wages of otherwise identical workers are higher in districts with a higher concentration of human capital. A constant-elasticity-of-substitution model of local labor markets with human capital externalities (spillovers from education) and no scale effects presented in Moretti (2004) shows that wages of less educated workers may increase in regions experiencing a rise in the share of highly educated workers because of imperfect substitution across skill types. Therefore, to provide qualitative evidence on the existence of spillovers, Moretti relates the wages of highly educated workers to the share of these workers in local labor force.[40]

A fundamental problem with identifying the spillover effect is the potential presence of locality-specific unobservable characteristics affecting both wages and the share of highly educated workers.[41] The Silicon Valley boom is a prime example of such local-demand-shock bias. However, given the communist miss-allocation of resources, one can plausibly think of the 1991 share of district college population as historically predetermined. Further, Moretti (2004), in his analysis of US city data, uses the presence of a college in the 19th century as an instrument for the local human capital concentration. Similarly, one may argue that the presence of a public college, setup under of before Communism, is also orthogonal to district-specific current technology mix.[42]

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[40] For a novel identification strategy see Ciccone and Peri (2004).

[41] There is also a potential bias from individual unobservables, which, however, is rejected by Moretti (2004) in his analysis of US city wages.

[42] A potential criticism of the strategy used in this section of estimating educational spillovers is that it is not clear

Table 4: District Wages and Share of College-Educated Population

	(1)	(2)	(3)	(4)
	Average Wage		College Wage	
1991 % College	1.244	0.592	2.364	-0.520
	(0.300)	(0.432)	(0.403)	(0.588)
2001 % College	0.710	0.401	1.218	-0.233
	(0.225)	(0.289)	(0.385)	(0.430)
Prague and Brno	Yes	No	Yes	No

Notes: Each estimate is based on a separate regression. The dependent variable is the district average adjusted wage for all workers or for college educated workers. Robust standard errors in parentheses. The regression is weighted using the number of observations in each district group.

The first two columns of Table 4 present estimates from regressions of district average log-wages adjusted for firm and worker characteristics including their years of education[43] on the districts' population share of college graduates in 1991 (top panel) or on the share of college degree holders in 2001 district labor force instrumented with the presence of public college in the district (bottom panel). There is support for a positive relationship between the concentration of college education in a district and its average wages after controlling for the individual own-education effect, but this comes from the specifications including Prague and Brno, which may be suspect of demand-shock bias. Indeed, additionally controlling for FDI per capita in unreported specifications renders the coefficients from column (1) insignificant, while the estimates from column (2) remain similar, albeit

why spillovers should occur at a local labor market level as opposed to the firm level or the national level. Having matched employer-employee data allows me to control for firm average educational attainment, but I cannot fully control for worker heterogeneity because I cannot match workers over time. I do find a positive coefficient on the firm level of human capital in a regression controlling for individual education, but it is not clear how this finding relates to the theory of migration divergence, which is the focus of this paper.

[43] These average wages are the district fixed effects from national regressions with the listed control variables.

somewhat smaller and marginally significant.

Next, columns (3) and (4) present the actual test for locality spillovers from the presence of highly educated workers: the estimates from regressing average district wages of college educated workers on their share in district population in 1991 and on their instrumented share of labor force in 2001. The results are qualitatively similar to those presented in columns (1) and (2). Relying on all districts, including the two major cities, there is indeed strong positive spillover effect. However, excluding the two main cities, which happen to be also the main recipients of FDI, or, alternatively, controlling for FDI per capita, results in parameter estimates not significantly different from zero.[44]

5 Conclusions

This paper estimates the regional variation in returns to education in a post-communist economy and links the local economic outcomes to recent economic theory on skill-biased migration. The evidence on Czech districts' educational composition and wage structure provides support for economic theory of regional divergence driven by concentration of human capital. Areas with a higher concentration of human capital experience a larger increase in their human capital endowment, and have higher returns to education. There is also some weaker evidence that these regions have higher wages beyond the effect that education has on individual wages. The existence of boom regions and rust belts in the EU-8 economies may therefore arise partly because of educational inequalities, which reinforce themselves through selective migration and/or educational production.[45] This finding supports the implicit motivation of the EU regional programs implemented within the structural and cohesion funds, which take the view of the "increasing returns" literature, namely

[44] I have also estimated the effect of the concentration of college education in a district on the wages of less educated workers and most of these unreported coefficients were positive and significant, even after excluding the two major cities. This evidence is consistent with imperfect substitution across skill types.

[45] In the US, Glaeser and Saiz (2003) find that cities with more educated populations grow faster than comparable cities with less human capital thanks to a higher increase in productivity.

that economic integration results in a concentration of the most productive factors in the most advanced regions and increases regional inequalities (Canova, 2001).[46]

[46] However, while the results presented here are suggestive of increasing returns and concentration of most productive factors, they correspond to very small regions (NUTS4 level), while the objective of the EU regional policies is to equalize factor endowments and income at the level of larger territorial units (NUTS2/NUTS3).

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Appendix: Wage Data Description

To measure local relative wages, I use a 2001 Czech national employer survey, the Information System on Average Earnings (ISAE), in which firms report hourly wages of their employees.

The worker data consist of hourly wages, gender, education (the highest degree obtained), and age for all employees of the surveyed enterprises. These wage records are drawn directly from companies' personnel databases and correspond to social security quarterly wage records. (Each quarter, employers calculate for each worker an average hourly wage, defined as total cash compensation including bonuses and other special payments divided by total hours worked for that quarter. This wage is then used in setting workers' sickness and unemployment benefits.) The uniformity of the wage definition and the use of personnel records minimizes the extent of reporting errors likely present in household survey data. Unfortunately, education is missing for 8% of workers and this part of data is excluded from the analysis. The 2001 analysis-ready sample covers 805,767 workers in 2,240 firms.

The 2001 ISAE firm sample is based on a 2000 stratified random sampling conducted by the Czech Statistical Office within the Eurostat's Structure of Earnings Survey program. Only firms employing more than 10 workers are sampled and the sampling rate is close to 100% for firms employing over 1000 workers. The data include over one third of the entire Czech enterprise employment and cover all firm size categories, and industries, except the public budgetary sector of health, education, and public administration.

The average number of firms (workers) observed per district is 41 (10,863) and there is obviously strong sampling variance at the local level, especially in terms of firm size and industrial structure. Therefore, the wage data used in this paper consist of individual log-wage residuals from a national regression with firm size and two-digit industry controls as well as with worker-specific controls (gender, experience and its square). The residuals in these national regressions are clustered at firm level to correct inference for the inter-dependence of worker unobservables within firms.

These adjusted wage data are then used to estimate district (i) average wages by education (district-education fixed effects), and (ii) returns to education. The latter consists of district-specific regressions controlling for individual education. The implicit assumption embodied in the estimation of district relative wages is that within the Czech districts, which average 100 thousand inhabitants and a few dozen kilometers in diameter, labor markets are integrated, labor is fully mobile, and the within-district wage structure can therefore be captured using a small sample of firms. The interpretation of the estimates of district average wages is, however, affected by the necessity to 'filter out' the industrial composition of the sampled firms, which itself is a reflection of the local industrial structure, albeit a noisy one.

Finally, when district-level second-stage regressions are performed, regressing district wages or returns on other controls, these are weighted by either the number of district observations (for average wages) or by the inverse of the variance of district-specific estimated slope coefficients (for returns to education). For a similar two-step procedure see Moretti (2004).