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Convergence across the four Central and Eastern European states: Panel Data Approaches

Master dissertation

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Annotation

The aim of the work is to analyze the convergence in the Czech Republic for the period of 1996-2006. The paper is based primarily on the Barro and Sala-i-Martin's theories of convergence of sub-national territorial units. The regression results proved assumptions to be realistic.

The main model concentrates on a panel data approach that captures the extent to which new transport infrastructure influences within-nation regional convergence.

This paper developed a regional approach to evaluate the impact of transport infrastructure, human capital and migration in four Central and Eastern European countries – the Czech Republic, Hungary, Poland and the Slovak Republic. The aim is to present an overview of the convergence process of the Czech regions between 1996 and 2006.

A neoclassical growth model is used as a framework to study convergence across the 14 administrative units of the Czech Republic. Data on gross value added per capita are exploited.

Keywords

Beta-convergence, determinants of convergence, transition

Statement

1. This statement is to confirm that this paper is a product of my own work and also to confirm that I used the listed sources in producing it.

2. I agree that the paper can be checked for research and studying purposes.

Prague, 28 May 2010 Daniyar Akhmetov

1. Introduction

The issue of within-nation development paths has been extensively explored with regard to the US states, EU NUTS regions, Japanese prefectures, Canadian provinces and Australian states, where data are robust and widely available. Although the issue is higher on the agenda of developing and transition economies, there have been few studies that analyzed within-nation convergence in this type of countries, for example, in Central and Eastern Europe.

The aim of the work is, therefore, to examine the occurrence of *β*-convergence in the Czech Republic, which is a middle income transition economy. The research questions are as follows:

- *What is the linkage between transport infrastructure, human capital and migration in closing the gap between leading and lagging regions?*
- *What is the impact of economic structure on beta-convergence?*

The paper is organized as follows: section “Review of empirical literature” discusses theoretical and empirical analyses of the researched subject area; section “Development of

estimable model" presents the econometric model and approaches adopted; section "Data and descriptive statistics" explores various measures of convergence and other data; section "Estimation and economic interpretation" describes the analysis itself and presents the empirical results; and section "Conclusions" summarizes the findings.

2. Review of empirical literature

The theoretical foundations of these issues can mostly be found in endogenous growth theory, new economic geography and macro-economic literature.

2.1.1. New Economic Geography

The economic geography framework was developed by Masahisa Fujita, Paul Krugman, Anthony Venables, and others in the early 1990s, and deals with the link between infrastructure and economic activity. The spatial distribution of firms, labour and assets is added as an additional dimension, for infrastructure project means making rival decisions on the place that will serve limited number of users. Economic agents will behave according to the availability and quality of local infrastructure.

In their book "Frontiers of the New Economic Geography" published in 2005, Masahita Fujita and Tomoya Mori explored the forces behind spatial concentration of economic activities. They distinguished "first" and "second nature": "to some extent, economic activities are spatially concentrated because of dissimilarities in such natural features as rivers, harbors and mineral deposits, or "first nature". However, the impact of the first nature on the spatial distribution of economic activities is not difficult to explain within the traditional economic theory based on competitive paradigm. Thus, the focus of this paper is on recent contributions to economic modeling of endogenous mechanisms (or second nature) leading to agglomeration."[1]

Increasing returns, often seen as arising from economies of scale or localised technological spillovers, generate a process of circular, cumulative causation leading to

[1] Fujita M., Mori T. 'Frontiers of the new economic geography'. Papers in Regional Science, Institute of Developing economies 2005, P. 4

decreasing costs of production and increasing wages. This gives rise to a cumulative process of agglomeration and all industry and workers move to one region. The balance between agglomeration and dispersion is determined by transport costs.

As they fall, both capital and labour will flow from small markets to richer regions with larger market sizes. The allowed factor mobility and subsequently increased agglomeration lead to the growth of competition and clustering. Altering factor mobility is critical for the prospects of poorer regions as public infrastructure investments in one location can draw production away from other locations or provide access to adjacent locations not previously accessible[2]. Boarnet (1998) shows that highway projects in California counties provide benefits to the investing counties at the expense of other counties within the state.

Boarnet analyzed negative output spillovers from public infrastructure in a linear production-function framework and found that "when input factors are mobile, public infrastructure investments in one location can draw production away from other locations"[3].

2.1.2. Endogenous Growth

The endogenous growth model emerged in the 1980s and emphasized that economic growth was a product of economic system rather than arisen from outside.

In neoclassical growth models for closed economies, as presented by Ramsey (1928), Solow (1956), Cass (1965) and Koopmans (1965), the per capita growth rate tends to be inversely related to the starting level of output or income per person. In particular, if economies are similar in respect to preferences and technology, then poor economies grow faster than rich ones.

Much of the empirical growth literature has evaluated growth theories by fitting regressions that relate the average growth rate of per-capita output over some time period for a sample of countries to initial per-capita output and country.

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[2] Lall S., Yilmaz S., 'Regional economic convergence: do policy instruments make a difference?'. World Bank Institute, Springer 2001, p.154

[3] Boarnet M.G., 'Spillovers and locational effects of public infrastructure'. Journal of Regional Science, Wiley 2002, abstract.

Alternatively, the mainstream endogenous growth models regard investment as an endogenous factor and technology as an exogenous one: disparities arising from differences in regional capital-to-labor ratios diminish over time and both trade and factor flows tend to equalize factor prices. Thereby, the theory anticipates unconditional long-run convergence, or conditional or club convergence.

2.1.3. Macro-level Empirical Studies

Macroeconometric research based on cross-country, cross-state or cross-region data has a number of drawbacks. One aspect that is relevant to infrastructure proxies is the fact that, as long as the variables used to capture some dimension of infrastructure are in fact aggregates of different underlying aspects with separate causal relationship with the outcome of interest, the aggregate estimated effect will depend on the arbitrary weights used to define the right-hand side proxy. This is especially relevant for public capital proxy, but may also affect physical indicators.

Another flaw is that even when studies have been technically sound, the usual macroeconometric measures have suffered from inescapable limitations due to the nature of data. Combes and Lafourcade (2005) show that while simple time or distance measures do relatively well in a cross-section setting, they very imperfectly capture variations in transport costs in a time-series perspective. So, the problem is that they do not allow for the decomposition of the sources of variations in transport costs resulting from changes in the regulatory framework, the identity of operators (i.e. privatization) and the nature of the political economy process that drives investments (Straub 2007). The inclusion of such data could be used more systematically to analyze how the overall provision of infrastructure investments and the quality of services is affected by the above-mentioned aspects. The sectoral coverage should also be as inclusive as possible. For example, transport should not include only roads but also ports, airports, railways.

At present, the private sector still represents a small share of overall infrastructure spending and it is not likely to grow substantially in the short term.

Other policy measures, such as tax breaks in the backward region, progressive income taxes and centralized wage setting with subsequent social transfers to the unemployed must be neutralized.

2.2. Convergence

There appear to be two main measures of economic convergence. These are the *sigma (σ) convergence* and *beta (β) convergence*. The *β-convergence* occurs when the partial correlation between growth in income over time and its initial level is negative.

2.1.3. Unconditional β-convergence

Unconditional (absolute) β-convergence is when poorer economies tend to grow faster than wealthier ones (Barro and Sala-i-Martin 1995, Sala-i-Martin 1996). The theoretical foundation for unconditional *β*-convergence is the standard neoclassical growth model by Barro and Sala-i-Martin (2004):

$$(1/T)\log(y_{it+T})/y_{it}) = \alpha - \beta \log(y_{it}) + \varepsilon_{it}, \quad (1)$$

where $y_{it} = Y_{it}/Y_t$ is per capita GDP in the i^{th} region relative to the average for the sample of regional economies under investigation, $(1/T)\log(y_{it+T})/y_{it}$ is the annualized rate of growth of relative per capita GDP in the i^{th} region over the study period between t and $t+T$, and $\log(y_{it})$ is the logarithm of relative per capita GDP in the i^{th} region in the base year t. If $0 < \beta < 1$, the data set is said to exhibit "absolute" *β*-convergence: there is a long-term tendency for per capita GDP to equalize across economies. The value of *β* measures the speed of the convergence process.

Under certain conditions, a negative coefficient on initial level of regional GDP per capita may not imply a decrease in interregional income disparity, for example in a situation where poorer regions grow fast enough to overtake the richer regions.

Another possible issue with this approach is the fact that the initial level of regional GDP per capita might be correlated with regional characteristics affecting growth. Regional characteristics are included and country-level (and later regional) fixed effects are added to control for this.

2.1.4. Conditional β-convergence

Conditional β-convergence becomes relevant when regional economies are not structurally similar and welfare or output measures do not converge to the same level but the differences across regions become stationary and growth rates are the same in the long run. Martin and Sunley (1998) argue that it is necessary to hold the steady state of each economy constant in order to test for conditional β-convergence. One method of doing this is to introduce additional structural variables in the basic growth regression. This method was used by Barro (1991), and Mankiw, Romer, and Weil (1992).

2.2. Empirics

An important question that has been addressed in the literature is to determine the more appropriate proxies for infrastructure. These have either been some measures of public capital – such as investment in infrastructure, generally from public sources although not exclusively – or physical indicators.

There are at least two reasons why public capital figures are not very good proxies for infrastructure. Firstly, a significant part of investment in infrastructure is made by the private sector. Measuring infrastructure stocks using only public investment figures introduces systematic measurement errors and renders most estimates unreliable. Besides, the official costs of investments are often disconnected from their effective value, mostly because of governmental inefficiencies or institutional weaknesses (Prichett 1996). Secondly, infrastructure is often not a pure public good. In part because of its private sector origin, it is increasingly taking a private good nature and its services are being priced.

Physical infrastructure proxies have also suffered from three main problems. Firstly, they are not systematically available across suitable geographical units and time. Secondly, the indicators currently used are often relatively bad proxies of the services they are supposed to capture. Thirdly, the quality dimension of infrastructure services, which appears crucial to private operators, is almost completely absent from these indicators. Finally, there is a dichotomy between maintenance and private capital durability on the one hand and the

realization of new investments at the detriment of the existing stock on the other. New investments are preferred to maintenance for reasons that maintenance is tax-financed, while new investments rely on soft international loans, and new investments may have higher "political visibility" and shorter "horizon" than maintenance, which only has gradual effects on the quality of the infrastructure stock.

It should be obvious that measuring infrastructure stocks using only public investment figures introduces systematic measurement errors and renders most estimations unreliable.

2.2.5 Empirical Economic Geographic Studies

The predictions of new economic geography models are as follows: infrastructure policies that facilitate interregional trade between leading and lagging areas will increase spatial concentrations of economic activity in leading areas. These policies will also increase growth in the whole economy while reducing nominal income inequalities between areas and between workers and capital owners. By contrast, infrastructure policies that improve connectivity within lagging areas may enhance local economic growth but can slow the growth of the whole economy (Baldwin, Forslid, martin, Ottaviano, and Robert-Nicoud 2003).

2.2.6. New economic geography

Depending on the “geographic scale”, the market forces to be harnessed or supported differ. At a smaller scale, for example, an area within a country (a province or state) – geography poses different challenges than at a larger geographic scale – say, a country. At an even larger geographic scale – say, a group of countries that form a geographic region – the market forces that work toward integration can be blocked by even greater geographic and political obstacles.

Density is the most important dimension locally. Distances are short, and cultural and political divisions are few and shallow. The policy challenge is getting density right – harnessing market forces to encourage concentration and promote convergence in living standards between villages and towns and cities. But distance can be important as rapid urbanization leads to congestion, and divisions within cities can be manifest in slums and ghettoes.

Distance to density is the most important dimension at the national geographic scale. Distance between areas where economic activity is concentrated and areas that lag is the main dimension. The policy challenge is helping firms and workers reduce their distance from density. The main mechanisms are the mobility of labour and the reduction of transport costs through infrastructure investments. Divisions within countries – differences in language, currency, and culture – tend to be small. In Indonesia the potential profitability of firms in textiles and other sectors is negatively related to distance-to-density: more distance, less profit. This is true for distance-to-density within the country and for distance to an international port and thus to density in international markets. Again, lagging areas unable to attract investment and employment are those with a high distance-to-density. Besides, long distances raise transport costs and reduce factor mobility.

Division is the most important dimension internationally. But distance and density are also relevant. Economic production is concentrated in a few world regions that are also the most integrated. Other regions, by contrast, are divided. While distance matters at the international level, for access to world markets, divisions associated with the impermeability of borders and differences in currencies and regulations are a more serious barrier than distance. Having a large and dynamic economy within the neighbourhood can help smaller countries, especially in regions distant from world markets.

These three attributes of development – geographic unevenness, circular causation, and neighbourhood effects – have not always received much attention. They should, because they have radical implications for public policy.

1. **Geographic unevenness** – the first attribute of development – implies that governments generally cannot simultaneously foster economic production and spread it out smoothly.
2. **Circular causation** – the second attribute – provides hope for policy makers wishing to pursue progressive objectives. Rising concentrations of economic production are compatible with geographic convergence in living standards.

3. **Neighbourhood effects** – the third attribute – come with a principle for policy making: promote economic integration. Unevenness and circularity imply that it is more difficult for places left behind to catch up. But spillovers point to the promise for surmounting this handicap. Economic integration is an effective and the most realistic way to harness the immediate benefits from concentration to achieve the long-term benefits of convergence.

Countries for the most part are free to determine their openness to the outside world. But geography and history produce divisions over which countries have little or no control. These include being landlocked, being in a remote location (especially if combined with small size), and having a high degree of ethnic or cultural heterogeneity within and across borders.

The EU takes into consideration these dimentions. The EU regional or "cohesion" policy for the period 2007-2013 defines lagging areas as those qualifying for assistance under the "convergence objective", equated with NUTS2 areas with a GDP per capita of less than 75 percent of the EU average[4]. These areas are budgeted to receive around 71 percent of funds under the convergence objective. But, even in EU regional policy, funding is available on more favourable (and complicated) terms for those areas whose GDP per capita is not only less than 75 percent of the EU average, but which are in a country whose GDP per capita is less than 90 percent of the EU average. These areas are considered to be "more lagging".

Convergence targets include eliminating territorial disparities in economic development (economic cohesion) and in access to labour and income (social cohesion). This "cohesion" is matched by the EU regional policy, which allocates about 60 percent of its funding to support areas of low development (less than 75 percent of the EU average GDP per capita).

Accounting for 35 percent of total spending of the EU, the EU cohesion policy is translated into practice through structural funds (90 percent of spending) and the cohesion fund (10 percent). The Agenda 2000 package comes with a price tag of Euro236 billion with Euro 195 billion for structural funds. Agenda 2000's objectives include the development and structural

[4] http://europa.eu/pol/reg/index_en.htm, "Activities of the European Union – Regional Policy"

adjustment of lagging areas, the development of border areas and areas industrial decline, and the adaptation and modernization of education and training systems. The cohesion policy aims to improve economic performance of specific areas and help them catch up with the rest of the union.

Resource allocations of this scale to support integration may reflect the redistribution preference of member states, but do these policies stimulate overall growth? Are they paying for the "wrong" type of assets? Academic research shows that they are not well suited to maximizing aggregate economic growth because they try to promote spatial evenness and not agglomeration. Nor are they especially well suited to promoting catch-up by lagging areas. Traditional cohesion policies that provide "hard" infrastructure and assistance to firms are unlikely to increase the competetiveness of lagging areas. Moving away from these programs to support educational programs and institutional development could do much more.

Relying solely on spatially targeted interventions is a common mistake. It is far better to rely on institutions that work less noisily. In France the concentration of economic mass and convergence of disposable incomes between leading and lagging areas have been concurrent, producing a "scissors effect" in the geographies of production and disposable income. The effect appears to be driven not by spatially focused interventions, but by spatially blind or "universal" progressive income taxation, social security, and unemployment benefits. Although space is not explicitly considered in such policies, their effects and outcomes can vary considerably across locations. As the base of economic integration, such "institutions" capture the benefits of spatial concentration of production and deliver convergence in living standards.

There are three types of spatial policies:

1. **Institutions** (spatially blind policies). The term is used here to categorize policies that are not explicitly designed with spatial considerations, but that have effects and outcomes that may vary across locations. These include such national policies as the income tax system, intergovernmental fiscal relations, and governance of land and

housing markets, as well as education, health care, basic water and sanitation, and other government initiatives.

2. **Infrastructure** (spatially connective policies). The term is used here as shorthand to include all investments that connect places and provide basic business services, such as public transportation and utilities. These include developing interregional highways and railroads to promote trade in goods – and improving information and communication technologies to increase the flow of information and ideas.
3. **Incentives** (spatially focused policies). The term is used here to include spatially targeted measures to stimulate economic growth in lagging areas. These include investment subsidies, tax rebates, location regulations, local infrastructure development, and targeted investment climate reforms, such as special regulations for export processing zones.

The experience of the EU and the United States in addressing spatial equity with aspatial tax system is constructive. Skeptics might counter that the coverage of the tax system is low in developing countries and that tax administration is weak. Besides, spatially blind tax and transfer policies may not be good enough for forming the bedrock of public policies to integrate countries spatially and help them benefit from concentration and convergence. Depending on their conditions, nations need a broader range of instruments for domestic integration. The challenge of economic integration can be seen as reducing the distance between people – especially the poor – and economic opportunity. Misplaced population densities, and barriers to mobility of workers and entrepreneurs between leading and lagging areas posed by international divisions, complicate the challenge.

In this regard, labour migration (both within and across countries) is a force behind cross-regional economic growth and convergence of income and added value. Within countries, the accumulated empirical evidence shows that labour migration increases the earnings prospects of people who move. It also shows that labour migration contributes to aggregate growth by

improving the distribution of labour, driving concentration. And by clustering skills and talent, migration drives agglomeration spillovers.

Whether couched in a classical framework or in the recent models of "endogenous growth," where people are free to move, they will move to compete away differences in wages between locations. Since higher wages at the destination neglect an initial shortage of workers relative to capital – or a large endowment of capital per worker – the arrival of new migrants will slow the accumulation of capital per worker and the growth of wages. In contrast, the accumulation of capital per worker in the places migrants leave will speed up as they go, accelerating wage growth for workers who stay behind. By this mechanism, incomes in different locations are predicted to eventually converge.

In a model that allow for labour mobility, raw labour tends to migrate toward richer economies, which have higher wage rates. This movement of persons lower the capital-labour ratio in places with initially high ratios; hence, diminishing returns to capital set in more rapidly and the convergence coefficient, B, is higher for any given parameters of preferences and technology.

With trade, the mobility of people is probably the most potent mechanism for integrating areas of low economic density with markets of high density. But for internal migration to bring about a convergence in living standards, large population movements may be necessary over generations.

The large differences in economic output will likely remain significant for some time. Among the main reasons are significant differences in the quality of domestic institutions, in the innovation dynamics of firms, and in the skills of the labour force. Assessing the benefits from integration thus requires a long time horizon, as increased labour mobility, investment in private and public capital, and other structural changes accelerate growth in lagging member countries.

People moving to economically dense areas contribute to production and boost their incomes. But they also increase competition among workers in dense areas, reducing it in less

dense areas, and contributing to the convergence of living standards between low- and high-productivity areas. Thus, labour mobility distributes labour from low- to high-wage administrative units, converging per capita incomes.

Besides, human capital flows to economically leading places. At every spatial scale, migration is the way that people who invest in education and skills realize the returns on their investment.

Comparable households enjoy much higher per capita spending if they migrate within their own district or to another district than if they stay in their native area. Therefore, in countries where lagging areas have large numbers of the poor, but few impediments to their mobility, institutions that promote mobility should be augmented by spatially connective infrastructure. Investments in infrastructure that increase the flow of goods, people and information would aid economic concentration and spatial convergence in living standards.

Migration in the four CEE countries is not hampered by ethnic, confessional or linguistic differences, as after the World War II, the societies in the four nations became ethnically homogenous.

Basic health and education indicators show improvements in almost all world regions, but there is some divergence in incomes between the richest and poorest regions. The human capital is also a development outcome that raises the quality of life for individuals.

Economic development tends to be accompanied by an initial divergence in living standards between countries, followed by convergence.

The increasing inequality between regions within a country reverses as lagging countries benefit from growth spillovers from leading countries. Some countries within a region may initially prosper more than others, but, in the long run living standards converge.

Because poorer countries start from a far lower level, however, their percentage improvements are much higher, suggesting eventual convergence.

Internationally, divergence in incomes continues for a while, and convergence is slowest. The stylized pattern of divergence followed by convergence is a hallmark of other modern-day developed countries.

History points to persistent spatial divergence in living standards in today's developed countries in their earlier stages of development, followed by slow convergence many years after they attained high income.

Spatial disparities in living standards follow an inverted-U path, widening in the early stages of economic development, and remaining high for a long period before slowly converging.

Second, in fast-growing regions, there initially is divergence as the leading regional economies pull away, but later there is convergence as poor countries benefit from growth spillovers and begin to catch up over time.

The influences of history and specialization are consistent with the observed stability in the relative city-size distribution and the industrial concentration in specific cities over time. Within countries the relative sizes of cities tend to remain unchanged. Among urban specialists, this phenomenon is often represented as a recurring relationship between a city's size relative to the largest city in the country, known as Zipf's law: a city's population size relative to the primate city is inversely proportional to its rank in the national hierarchy of cities. There is also persistence in the industrial concentration in specific cities.

Adverse physical geography generally increases economic distance, reducing trade of goods and services and the flow of labour, capital and information, making delivery of public services harder. Connective infrastructure improvements are necessary for spatial integration. In addition, spatially blind education policies of improving schools can improve welfare in lagging areas.

Falling transport costs bring closer economic integration within and between countries. The fall is caused by large infrastructure investments and breakthroughs in transport technology.

Massive investment in road construction completely changed interregional trade: they reduced intercity and interarea transport costs.

Better transport technologies developed over the past two centuries have increased the volume of trade and radically altered its nature. Before World War I transport costs declined enough to make large-scale trade possible, but only between countries that were dissimilar. They happened to be countries that were distant, because big differences in climate and natural endowments usually meant the countries were in different parts of the world (Indonesia and the Netherlands, for example). During the second wave following World War II, transport costs fell enough for small differences in products and tastes to fuel trade. This lead to a rise in trade between countries that are similar (for instance, Argentina and Brazil), which often happen to be neighbours. As transport costs fall, physical geography matters less.

A decline in transport costs – with increasing returns to scale – generally means more spatial concentration of production. Recent thinking in economics has emphasized the importance of transport costs in development. With high transport sots, large economies of scale will remain unexploited, and production inefficient. Efficient production is more specialized. When transport costs fall, spatial differences in production and economic growth will increase, both within and between countries.

With falling domestic transport costs, economic production should have become more evenly spread within countries. With lower costs of transporting and communicating internationally, countries should have traded more with distant partners. What happened was the opposite. Falling transport costs have coincided with grater economic concentration within countries. And while countries now trade more with everyone – exports as a share of world production quadrupled to 25 percent over the last three decades – trade with neighbours became even more important.

Why did this happen? The answer lies in the growing importance of scale economies in production and transport. As transport costs have fallen, they have allowed greater specialization

and radically altered the location of firms and the nature of trade. With high transport costs, firms had to be near consumers. But as transport costs fall, they can avail of internal, local, and urban economies of scale, and transport the product to consumers. Internationally, the same thing. With high transport costs, nations trade to fulfill basic needs and when transport costs fall, the trade switches to satisfy a variety of wants.

Developing countries should pay more attention to transport and communications regulations to reduce transport and trade costs. The new economic geography had inadvertently contributed to an exclusive policy focus on “hard” infrastructure. The most critical policy-related aspects – the naturally monopolistic nature of transport – have been assumed away. Developing countries should do more to address the negative effects of market structure in the transport sector.

The investment in domestic transport created large and integrated home markets. Tariff barriers remained low, and international trade benefited from technical and organizational progress.

Regional transport infrastructure reduces the economic distance between trading partners, both within the neighbourhood and leading world markets. Like any other infrastructure, transport raises productivity.

By upgrading and pooling infrastructure within a regional industrial development program, input costs could fall and cotton-based industries such as textile and garments could become competitive in the global market. Such an initiative would require a strong commitment from the participating countries and support from regional associations and the international community.

By and large, transport infrastructure offers a range of methods to bridge the economic distance between leading and lagging areas.

Recent research also explains two somewhat unexpected consequences of falling transport costs: (1) at the international level, trade infreases with nearby countries, not with those

farther away, and (2) within countries, improving transport infrastructure may lead to more concentration of economic activity, not less.

Falling transport costs lead to concentration within countries. The productivity and income benefits of agglomeration, driven largely by lower transport costs, are often difficult for planners and policy makers to accept. But they explain the second counterintuitive implication of falling transport costs. There is a strong belief that an equal distribution of transport infrastructure will induce an equal geographic distribution of economic activities. High concentration is seen as a problem, and the spatial redistribution of economic mass is expected to promote overall development. Massive transport infrastructure investments have been the central policy instrument to induce firms to move to lagging regions. But the outcomes were usually the opposite – the target regions lost production and workers to the leading regions.

Nationally, as leading and lagging areas within countries are connected through better modes of transport, production is more concentrated in the more economically dense areas to take advantage of agglomeration economies.

This means more concentration within developing countries, but – by allowing them to specialize at earlier stages of development and exploit economies of scale – it will help them converge to the incomes and living standards in the developed world.

Increasing returns to scale and spillovers from clustering – especially human capital-related spillovers – make clear the growth and welfare payoffs of policies that facilitate movements of labour from lagging to leading places. The implications for policy are powerful. Rather than an impending destructive tide of humanity, the swelling flows of people from villages to cities could be a boon for economic growth and the convergence of welfare. Moving from the local spatial scale, no the national, and then to the international, the benefits from clustering are the same – and the problems facing policy makers grow and become more complex. Put plainly, they do not want to lose people and human capital.

This is nothing new. Production in today's developed economies grew more concentrated until they reached high incomes. Concentration in Poland's leading xxx.

Each successful world region has, at some point, made significant and broad-based gains with basic labour-intensive manufacturing. This process initially led to a diversification of production as countries grew richer and consumers demanded more varieties. As economies in these regions expanded, production and employment in individual countries started to specialize in what they were best at, giving rise to interlinked networks or production trading intermediate goods among countries within the region. In countries that industrialized earlier, the service sector, including the research and design of products that will be manufactured elsewhere, now accounts for the largest share, by far, of employment and economic output.

The opportunity is that, while spatial concentration remains beneficial for production, increasing specialization allows concentration and scale economies within subsectors in which even small players can carve out a niche.

So, in rural areas, every additional worker, irrespective of innate talents or education attainment, has zero marginal productivity, but each potentially has a positive marginal productivity in manufacturing. This opens a gap in earnings and an incentive for labour to migrate from rural areas to cities in search of manufacturing jobs. Agriculture supplies an unlimited labour force to manufacturing, and the transfer of labour between the two sectors taken place through rural-urban migration. This migration continues until the "disguised unemployment" of workers in rural areas is absorbed into manufacturing in urban areas.

2.2.7. Role of transport infrastructure

One area in which macro-data may prove useful, is the study of how institutional, regulatory and political economy characteristics of countries or regions affect the amount and quality of infrastructure services provided at the sector level. In essence, researchers have been concerned with the timing of restructuring measures (before and after privatization), the implementation of regulation and, if so, the institutional aspects of it.

Persyn and Algoed (2009) opine that the effect of transfers which are able to increase infrastructure investment in backward regions cannot be predicted to foster growth and convergence. The authors find no clear-cut evidence that investment in transport infrastructure leads to higher growth in all regions or more so in initially poorer regions.

In addition to production factors such as labour and private capital, transport infrastructure plays a role as an input in production processes. An improvement of transport infrastructure services implies that a regional economy can make use of its private production factors in a more productive way. Better transport infrastructure means: lower capital and labour needs to be able to reach the same production level. There are essentially two ways for analyzing the productivity gains induced by transport infrastructure improvements. The first one takes place at the firm level by measuring carefully the reductions in (transport) costs which can be achieved by infrastructure improvements. The second one occurs at the aggregate regional level by investigating the contribution of the production factor infrastructure to regional production taking into account the contribution of other production factors. This entails the use of regional production functions.

2.2.8. Types of convergence

If the dispersion – standard deviation of the logarithm of relative per capita income or product levels –tends to decline over time across regions (i.e. each region converges to a common rate or level), a so-called *σ-convergence (dispersion)* is observed.

The existence of β-convergence will tend to generate declining dispersion or σ-convergence. However, since the latter also depends on the variance of the error terms or "shocks", this implies that although the long-term (steady-state) dispersion, falls with β (the strength of the convergence effect), it rises with the variance of the disturbance term. It is in this sense that β-convergence is a necessary but not sufficient condition for σ-convergence.

Another theoretical framework narrates that differences across structurally dissimilar regions become stationary and growth rates converge in the long run. This is a case of

conditional β-convergence. Martin and Sunley (1998) argue that it is necessary to hold the steady state of each economy constant in order to test for *conditional β*-convergence. One method of doing this is to introduce additional structural variables in the basic growth regression. This method was used by Barro (1991), and Mankiw, Romer, and Weil (1992).

Barro and Sala-i-Martin (1995) and Sala-i-Martin (1996) draw a useful distinction between two types of convergence in growth empirics: sigma (σ) convergence and beta (β) convergence. When the dispersion of real per capita income (henceforth, simply "income") across a group of economies falls over time, there is σ-convergence. When the partial correlation between growth in income over time and its initial level is negative, there is beta-convergence. Sala-i-Martin (1996) makes a distinction between conditional β-convergence (as described abotve) and unconditional (absolute) β-convergence, where poor economies simply grow faster than wealthy ones.

The idea of *unconditional β-convergence* is at the core of the new endogenous growth theory. A standard model is developed by Barro and Sala-i-Martin (1992) for unconditional *β*-convergence:

$$(1/T)\ log(y_{it}/y_{i,t-T}) = \alpha - [log(y_{i,t-T})](1 - e^{-\beta T})\ (1/T) + u_{i,t-T,t}, \qquad (1)$$

where $log(y_{it}/y_{i,t-T})$ is the first lag of annualized rate of growth of output in region *i* over the study period between $t - T$ and t; $\log(y_{it})$ is the logarithm of output in region *i* in the year *t*; $u_{i,t-T}$ is a distributed lag of the error terms, u_{it}, between dates $t - T$ and t; β is the convergence coefficient, which is the relative degree to which regions are said to converge absolutely when, in the long run, their wealth or output tends to equalize across them[5]. If $0 < \beta < 1$, there is an absolute β-convergence and, vice versa, if $-1 < \beta < 0$, there is an absolute *β*-divergence. The Barro and Sala-i-Martin's fundamental postulate is that the growth of low-income states exceeds that of higher income states[1].

[5] Barro R.J., Sala-i-Martin X.X., 'Convergence'. Journal of Political Economy, UChicago Press 1992, p. 228

The model does not include any shocks that normally have varying impact on different regions for several reasons. First of all, no major shocks were observed for the period of 1996-2006: the global financial crisis spelt over the economic sector only in September 2008 and reached Central and Eastern Europe with a significant time lag – beyond the analyzed period. Secondly, the agricultural sector and/or oil production constitute a minor share in the structure of a Czech region and, thus, any changes in the relative prices of agricultural commodities could not have had any adverse effects on the income or product levels of a region relative to the incomes or products of other regions.

Unequal distribution of population might lead to upward or downward bias of a disparity measure (Kessler, Lessman 2009). Fortunately, the classification of the Czech administrative units is the same for both the Czech National Statistical Office and the Eurostat Nomenclature of Territorial Units for Statistics classification level 2 (more known as NUTS 2).

The model (1) is extended by Lall and Yilmaz (2000) who adopted the following specification:

$$log(y_{i,t+T}/y_{it}) = \alpha - \beta\, log(y_{it}) + c_k Z_{ki,t} + d_i D_{i+T} + e_i T_{t+T} + u_{it+T}, \quad (2)$$

where "Z is a vector of k additional regional characteristics such as human capital and public capital; D is a vector of regional dummy variables with a set of regional coefficients d_i that can be interpreted as capturing specific regional characteristics; T is a vector of t time dummy variables included to capture trends in the economy, such that coefficients e_i capture the time specific nature of the rate of growth of regional income per capita"[6].

Physical and human capitals are control variables that have been shown in the literature to impact regional disparity. Romer (1989) posited that educated and skilled labour force is able to use capital more efficiently and, thus, refuted the Cobb-Douglas idea of decreasing rates of return[7]. Investments in transport infrastructure (employed as a proxy for physical capital) are

[6] Lall S.V., Yilmaz S., 'Regional economic convergence: do policy instruments make a difference?'. The annals of regional science, Springer 2001, p. 158

[7] Romer P.M., 'Increasing returns and long-run growth'. The Journal of Political Economy, UChicago Press 1986, p. 1004

also recognized as an important factor. The reasons for including transport variables are best summarized by Lall and Yilmaz (2000): "appropriate and efficiently supplied infrastructure has an inherent role in improving access to markets, reducing unit cost of production and generating consumer surplus by reducing cost of consumption, improving the general quality of life, as well as in attracting private investment"[8].

Transport infrastructure is not confined to roads, because the whole picture of its interactions with the development outcomes can be generated if airports, water- and railways are also included.

The analysis is extended by disaggregating transport infrastructure into two groups: capital expenditures and operational expenditures on all means of transport. Capital expenditures (CapEx / new investments) contribute to the fixed infrastructure and are depreciating over time. They are needed to expand the services to users of public goods. Operational expenditures (OpEx / maintenance expenditures) do not contribute to the infrastructure themselves and, as such, are not subject to depreciation. They represent the cost to keep transport infrastructure operating. According to Straub (2008), "one reason for that [structural decomposition] is the fact that the OPEX/CAPEX balance is likely to be crucially influenced by the amount of relative maintenance expenditures. Growth models imply that lower than optimal levels of maintenance expenditures will generate higher operational costs, both to run the infrastructure facilities and for private capital good that rely on them"[9].

The contribution of the above-mentioned production factors must be investigated, as the empirical evidence throughout the world has at best been mixed. In Italy, massive resources were transferred through a government-based channel, which contributed to developing regional infrastructure, including roads and schools, in the lagging South (so called "Mezzogiorno"), but the decades-long transfers did not change the position of the region relative to the national

[8] Lall S.V., Yilmaz S., 'Regional economic convergence: do policy instruments make a difference?'. The annals of regional science, Springer 2001, p. 154
[9] Straub S., 'Infrastructure and growth in developing countries: recent advances and recent challenges'. World Bank Policy Research Working Paper 2008, p. 17

average. The unemployment rate more than doubled till the end of 1980s, indicating a rapidly growing dependence of the South on fiscal transfers from the North[10].

3. Development of estimable model

A linear model is developed to determine the relative impact of selected variables on the compound average growth rate of regional GVA per capita over the 1999-2006 period:

$$(1)\ GROWTH_{i,t} = \beta_0 X_0 - \beta_1 GVA_{i,t-1} + \beta_2 ROAD_{i,t-1} + \beta_3 HUMK_{i,t-1} + \beta_4 LABOUR_{i,t-1} + u,$$

where the variables are:

$GROWTH_{i,t}$ = growth rate of regional per capita GVA measured relative to national average;

X_0 = Constant term;

$GVA_{i,t-1}$ = Initial regional per capita GVA relative to national average;

$ROAD_{i,t-1}$ = Growth rate of the length of roads in kilometers;

$HUMK_{i,t-1}$ = Growth rate of human capital measured by tertiary education (as percent of labour force);

$LABOUR_{i,t-1}$ = Growth rate of labour force;

t = Year of observation (1999 = 1 …2006 =9);

u = Independently and identically distributed error term.

The specification (1) is employed to test the link between increased transport infrastructure, human capital, net migration (proxied by the labour force) and convergence.

One of the assumptions of Classical Linear Regression Model is that the sample means are normally distributed. The only way to guarantee this is for the distribution of the individual

[10] Faini R., Galli G., Giannini C., 'Finance and development: the case of Southern Italy', Finance and development: issues and experience'. Centre for Economic Policy Research 1993, p. 159

observations from the sample to be normal. To avoid skewness, the variables are logarithmically transformed. Table 1 shows positive signs for all coefficients of the explanatory variables:

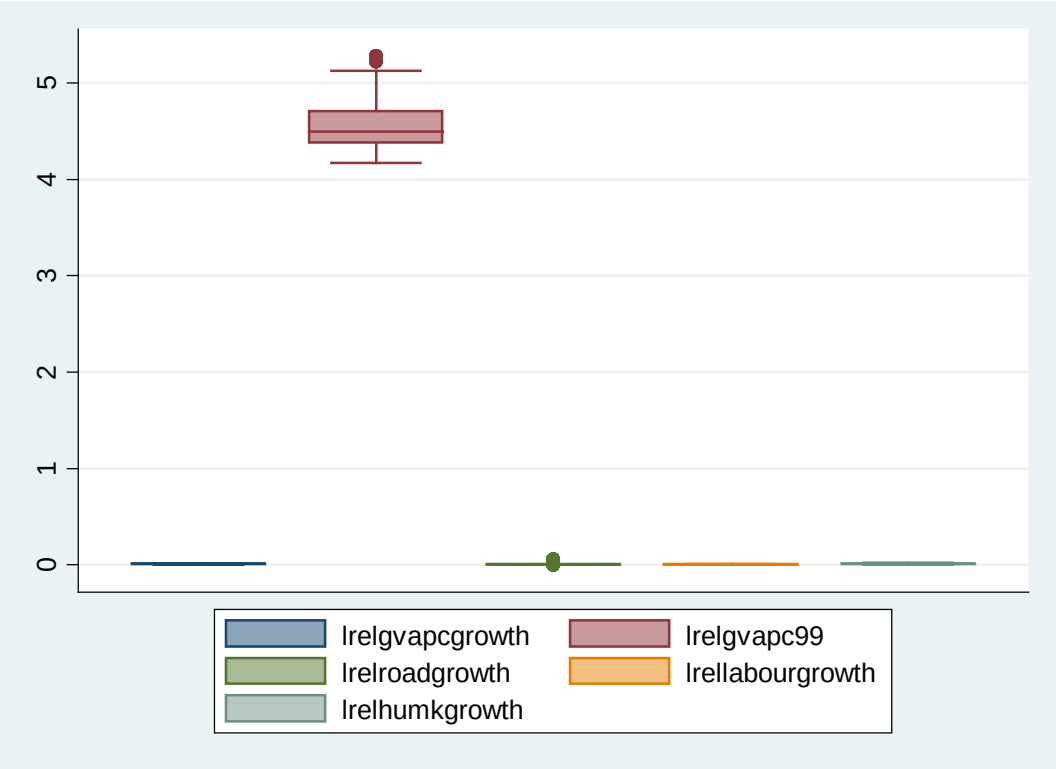
Table 1. Correlation matrix of regression variables:

	Growth of relative GVA per capita	Relative GVA per capita in 1999	Growth of relative road length	Growth of relative labour force	Growth of relative human capital
Growth of relative GVA per capita	1				
Relative GVA per capita in 1999	0.2124	1			
Growth of relative road length	-0.6815	-0.1631	1		
Growth of relative labour force	-0.2837	0.1249	-0.0485	1	
Growth of relative human capital	-0.1684	-0.0689	-0.4262	0.2759	1

The growth of relative GVA per capita has a strong negative correlation with the change in relative length of roads and, to less extent, with the growth of relative labour force and human capital. Interestingly, the relative length of roads is negatively correlated with the growth of relative human capital.

The Graph 13 with a box plot below reveals the presence of outliers and/or influential observations in the cases of the relative GVA per capita in 1999 and relative growth of road length.

Graph 1. Box plots of explanatory variables



Scatters of the afore-mentioned variables are plotted to further explore the potential outliers and/or influential observations. The abbreviations of the names of the regions are listed in Table 2 before the scatter plots.

Table 2. Regions of four Central and Eastern European countries

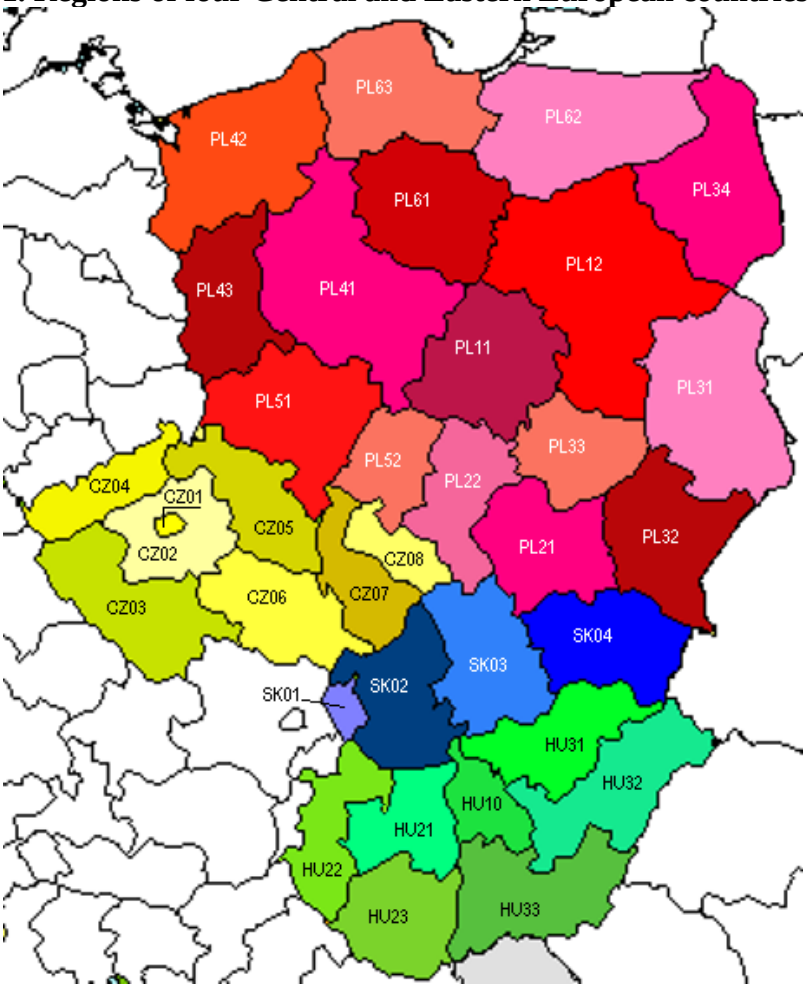
Czech Republic
- CZ01 - Praha
- CZ02 - Stredni Cechy
- CZ03 - Jihozapad
- CZ04 - Severozapad
- CZ05 - Severovychod
- CZ06 - Jihovychod
- CZ07 - Stredni Morava
- CZ08 - Moravoslezsko

Hungary
- HU10 - Kosep-Magyarorszag
- HU21 - Kosep-Dunantul/Central Transdanubia
- HU22 - Nyugat-Dunantul/Western Transdanubia
- HU23 - Del-Dunantul/Southern Transdanubia
- HU31 - Eszak-Magyarorszag/Northern Hungary
- HU32 - Eszak-Alfold/Northern Great Plain
- HU33 - Del-Alfold/Southern Great Plain

Poland
- PL11 - Lodzkie
- PL12 - Mazowieckie
- PL21 - Malopolskie
- PL22 - Slaskie
- PL31 - Lubelskie
- PL32 - Podkarpackie
- PL33 - Swietokrzyskie
- PL34 - Podlaskie
- PL41 - Wielkopolskie
- PL42 - Zachodniopomorskie
- PL43 - Lubuskie
- PL51 - Dolnoslaskie
- PL52 - Opolskie
- PL61 - Kujawo-Pomorskie
- PL62 - Warmino-Mazurskie
- PL63 - Pomorskie

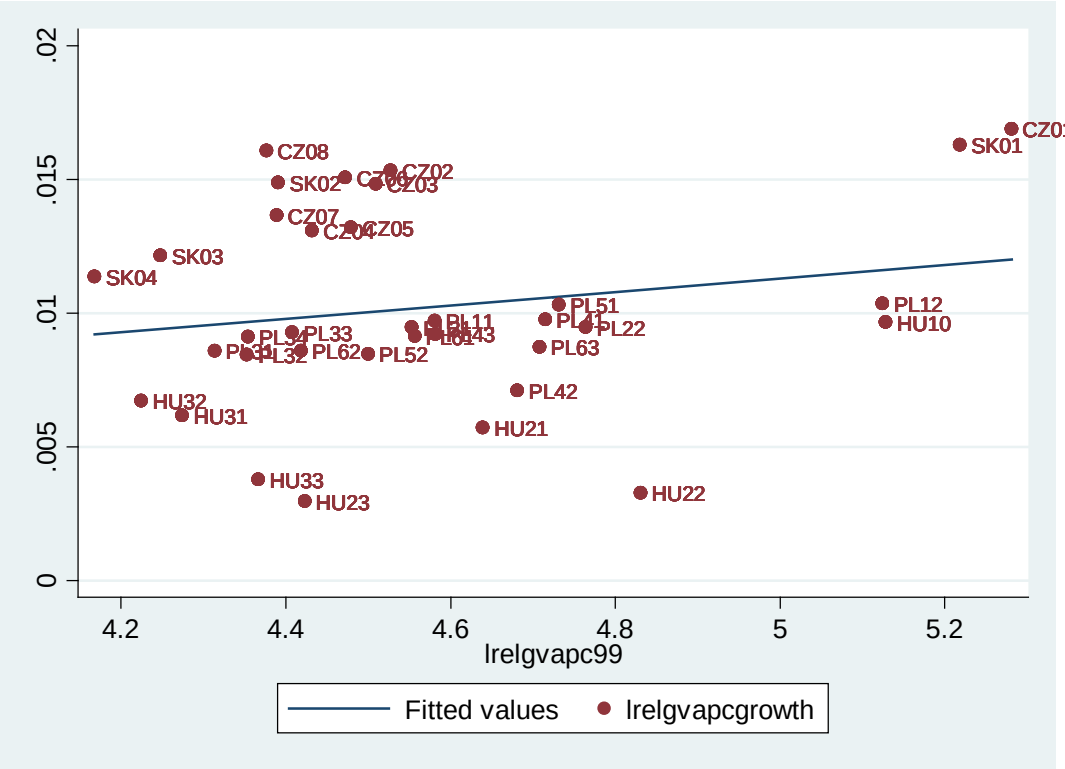
Slovakia
- SK01 - Bratislavsky Kraj
- SK02 - Zapadne Slovensko
- SK03 - Stredne Slovensko
- SK04 - Vychodne Slovensko

Figure 1. Regions of four Central and Eastern European countries

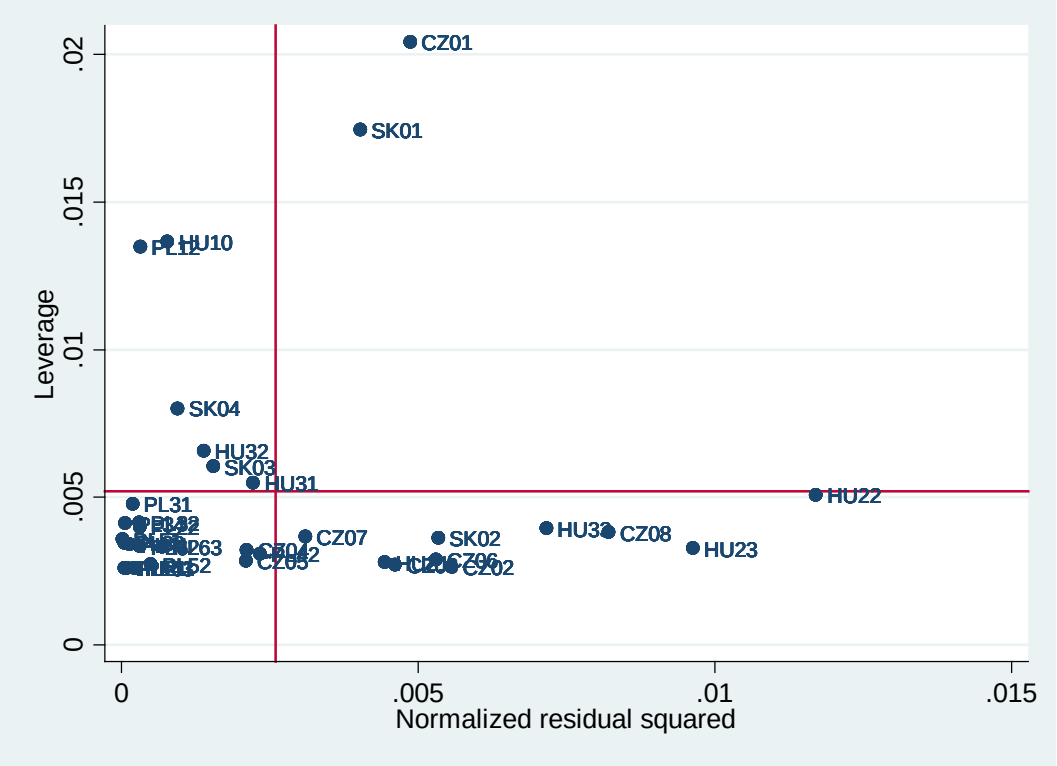


Source: Map is adapted from the Eurostat. Author's edition. See table 1 for names of regions

Graph 2. Scatter plot of the growth rate of relative real GVA per capita and its initial level

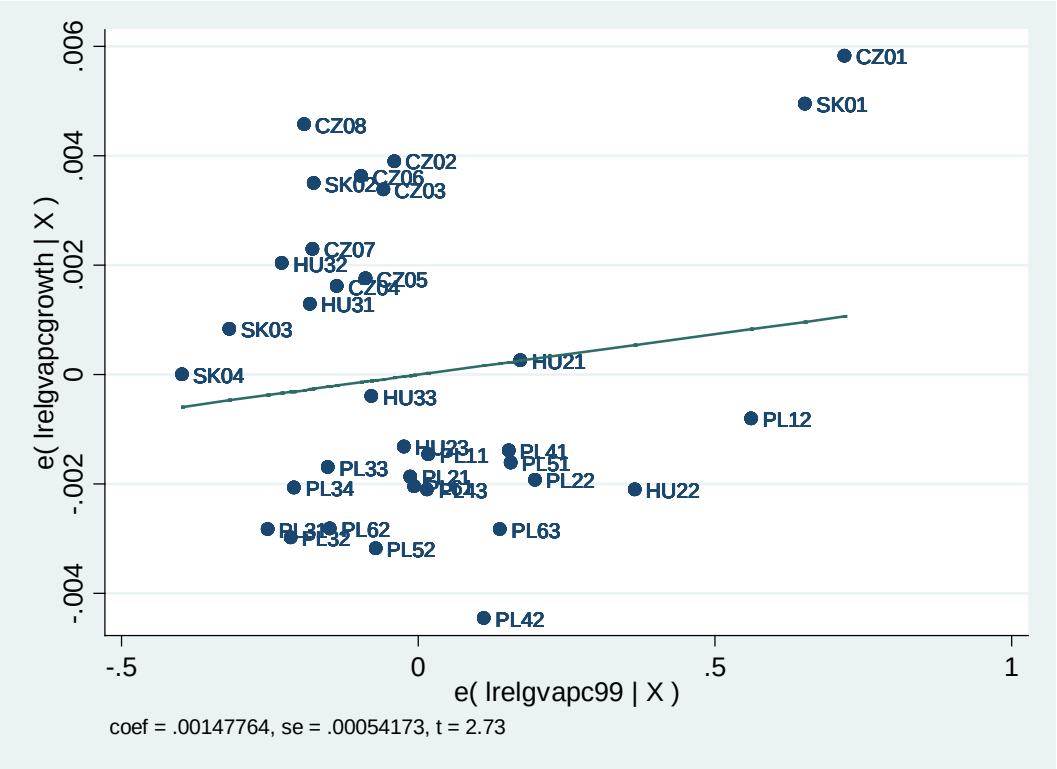


Graph 3. Leverage-versus-residuals square plot of the growth rate of relative real GVA per capita and its initial level



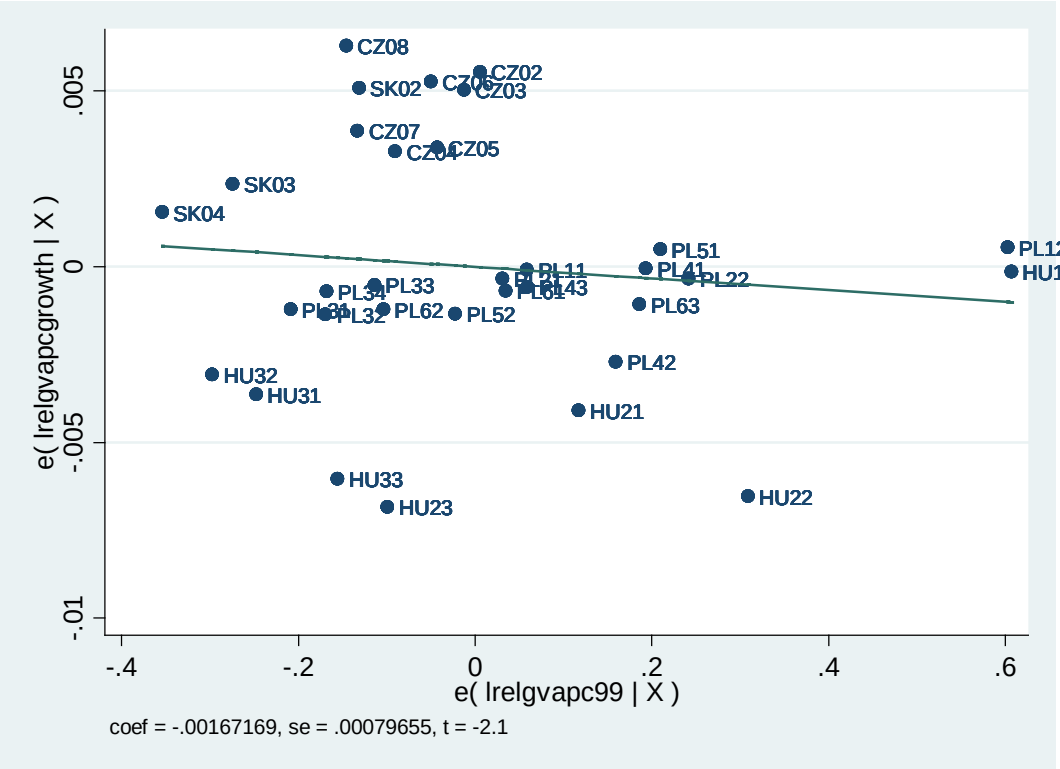
As we can see, Prague (CZ01) and Bratislavsky Kraj (SK01) have both the largest leverage and residuals. This is confirmed by an added-variable plot below.

Graph 4. Added-variable plot of the growth rate of relative real GVA per capita and its initial level



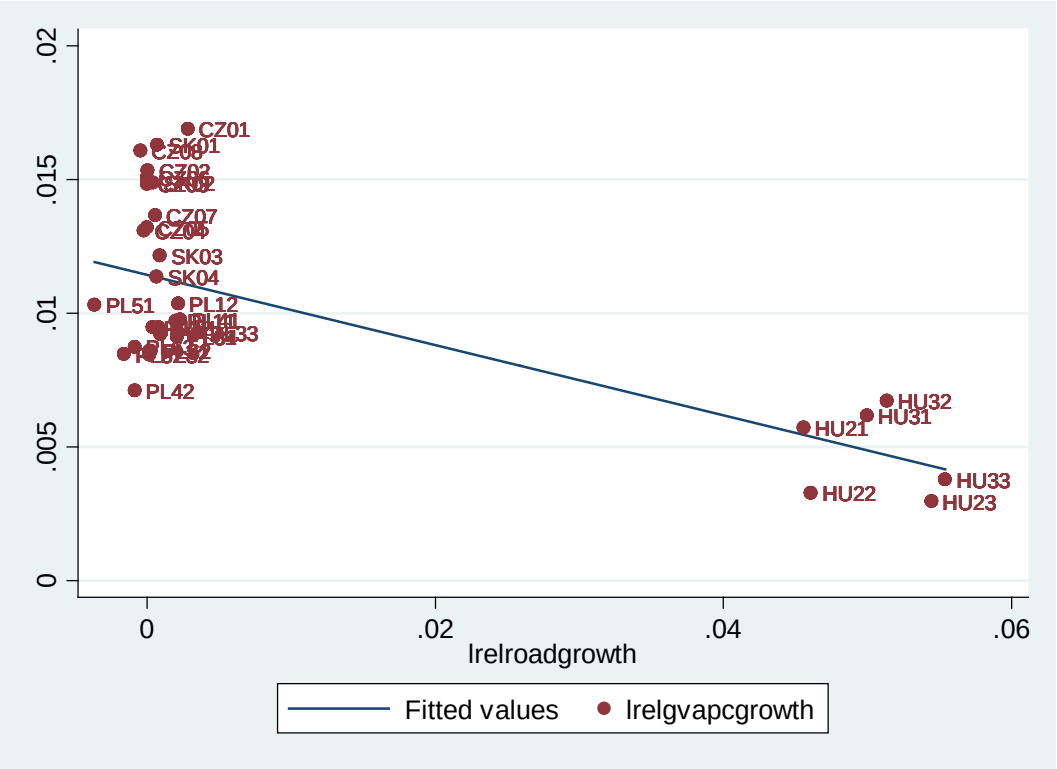
We can see how the regression line is trying to reach the extreme values of CZ01 and SK01. Many other observations also exert substantial leverage on the coefficient of the log of relative GVA per capita in 1999. Removing these influential points substantially changes the estimate of coefficients and the best-fit line.

Graph 5. Added-variable plot of the growth rate of relative real GVA per capita and its initial level after removing influential points

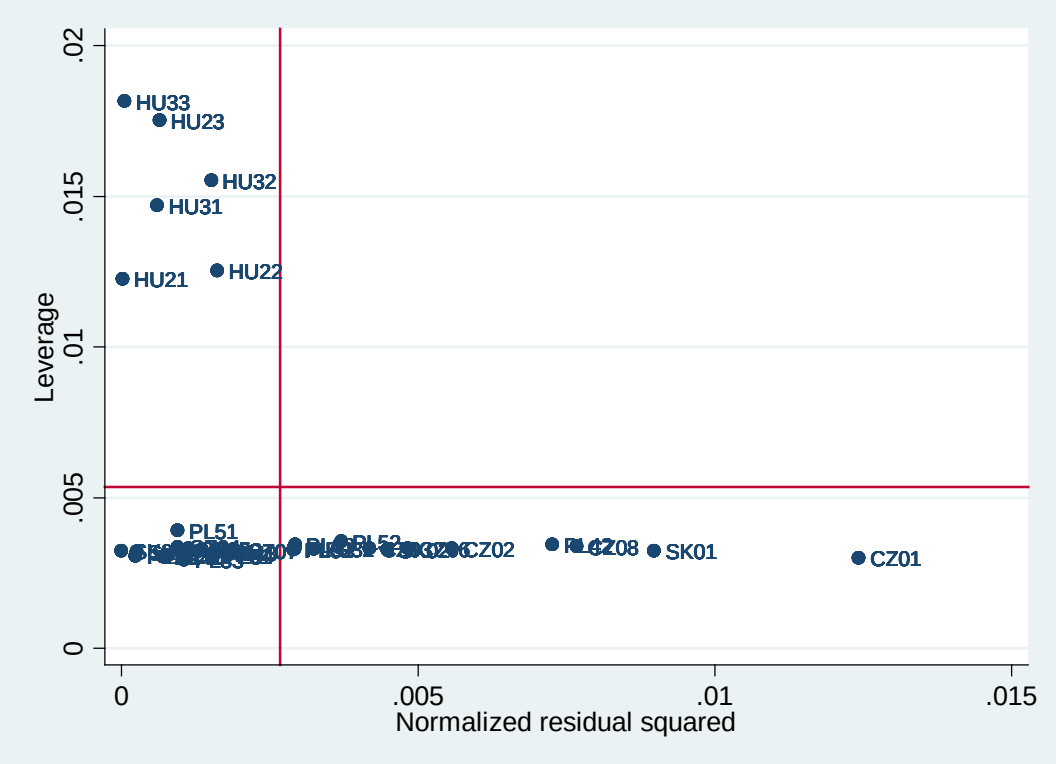


The scatter and leverage-versus-residual square plots below show observations with high leverage represented by Hungarian regions (HU21-HU33) and residuals with, again, Prague (CZ01) and Bratislavsky Kraj (SK01).

Graph 6. Scatter plot of the growth rates or relative real GVA per capita and relative length of roads



Graph 7. Leverage-versus-residuals square plot of the growth rates or relative real GVA per capita and relative length of roads



Although leverage points can have an effect on the estimate of regression coefficients[11], removing all Hungarian regions will render the estimation incomplete. Only observations for Prague (CZ01) and Bratislavsky Kraj (SK01) are dropped.

As none of the variables in the regression shows near-perfect linear relationship between each other, the issue of multicollinearity is mitigated and all variables are included in the regression. Finally, the functional form of the model is correct, and the assumptions of the Classic Linear Regression Model are satisfied.

4. Data and descriptive statistics

The original sample consisted of 32 variables and 385 observations for the period between 1996 and 2006. As the variables are observed for most of the entities (regions) and most of the time periods (years), the longitudinal data is balanced. However, missing and non-evenly spaced data introduced some technical difficulties. For this reason, the initial period was increased from 1996 to 1999. The data were obtained from the following databases: Eurostat New Cronos, OECD and the World Bank World Development Indicators. The Eurostat NUTS 2 territorial classification was preferred over the national statistical one as it is the lowest unit with available uniform data for most of the variables; "NUTS 1, a larger unit representing the major socioeconomic regions, often does not correspond to existing administrative units within member states"[12].

Previous researchers utilized different measures of wealth and output: regional personal income per head, regional gross value added, regional GDP per employee, and regional GDP per capita.

Both the net disposable income of households and net balance of primary income were vetted as they do not give precise picture of one's wealth. GDP per head was preferred to GDP as the differences in population growth across regions could have biased estimates. To neutralize

[11] http://www.ats.ucla.edu/stat/stata/webbooks/reg/chapter2/statareg2.htm
[12] World Bank Group, 'World Development Report 2009: Reshaping Economic Geography'. World Bank Publications 2008, p. 78

the impact of redistributory transfers (taxes and subsidies on products), the Gross Value Added was finally chosen as the basic variable[13]. The GVA was adjusted by the national GDP deflator with price bases varying for countries ('single deflation').

The analysis includes in the regression human capital, migration and transport infrastructure. By consensus, human capital is measured either as the fraction of workforce that have at least started (but necessarily completed) secondary education (Barro and Sala-i-Martin 1990, La Fuente 1997), or as the share of workers who have accumulated some amount of college education (Mankiw, Romer and Weil 1992), or as the ratio of university graduates per population (Fleisher, Chen 1996). The Mankiw et al. approach is adopted.

Data on regional labour mobility to richer regions, which not only affects the speed of convergence, but also might create a force towards divergence[14], is unavailable and, as such, is proxied by the number of employed workers. Transport infrastructure stocks were proxied by physical indicators of roads (in kilometres) as no capital or operational expenditures are at hand either.

The expected sign of the coefficients is "-" for β_1, β_2, β_3, and β_4 because it is assumed that higher growth of transport infrastructure and human capital relative to the national average will let migrants more fully explore their options in places with higher wage premium, thus putting a downward pressure on the growth of GVA relative to the other regions. The data on the Czech, Hungarian, Polish and Slovak administrative units provided by the Eurostat and OECD are deemed to be reliable.

5. Estimation and economic interpretation

Table 2 shows regressions for the CEE administrative units over the 1996-2006 period. The regression in table 2 includes only a constant and $\log(y_{i,t-T})$ as independent variable.

[13] United Nations website. Price and Volume measures
http://unstats.un.org/unsd/sna1993/tocLev8.asp?L1=16&L2=5
[14] Barro R.J., Sala-i-Martin X.X., Blanchard O.J., Hall R.E., 'Convergence across states and regions'. Brookings Papers on Economic Activity, The Brookings Institutions 1991, p. 111

Table 3. Regressions for the growth rate of relative real GVA per capita[i] and initial relative real GVA per capita[ii] across the four states, 1996-2006

Sample	*Year*	$\hat{\beta}$	R^2
Czech Republic	1996-2006	-0.0032425	0.0136
		(0.0031871)	[0.00108]
- Regions	1996-2006	-0.0032425	0.0136
		(0.0031871)	[.00108]
Hungary	1996-2006	0.0040304	0.2269
		(0.000859)	[0.00196]
- Regions	1996-2006	-0.0051424	0.2783
		(0.0010352)	[0.00128]
Poland	1996-2006	0.0017666	0.1554
		(0.0003123)	[0.00072]
- Regions	1996-2006	0.0009944	0.0365
		[0.0004003]	[0.00072]
Slovak Republic	1996-2006	0.0165771	0.9862
		(0.0003524)	[0.00018]
- Regions	1996-2006	0.0165771	0.9862
		(0.0003524)	[0.00018]

Sources: Author's own calculations using the Eurostat New Cronos and OECD databases (various years). The codes in the figure are transcribed in Table 1. The nominal GVA figures are in millions of euro (from 1.1.1999)/millions of ECU (up to 31.12.1998) and are divided by the GDP deflator (with 2000 as base year for the Czech Republic, Hungary and the Slovak Republic, and 2002 as base year for Poland). The standard errors are shown in parenthesis.
i. Growth is regional relative to national compound average annual growth rate of real GVA per capita between years $t - T$ and t, measured in logarithm: $(1/T) \log (y_{it}/y_{i,t-T})$. Both regional and national data are unweighted average values of the disaggregated data.
ii. The log of initial real GVA per capita is regional real GVA per capita relative to the respective country mean.

Table 4 presents the main results which show the role of changes in relative human capital, transport and migration – along with the initial GVA per capita – on the growth rate of relative GVA per capita in 35 administrative units of the four Central and Eastern European states for the 1999-2006 period.

Table 4. Panel estimations:

	Dependent variable: Growth of relative GVA per capita from 1999 to 2006	
Regressors	**(1)**	**(2)**
	0.0247601* **	**0.0324066*** **
Constant	(0.0020539)	(0.0024427)
	-0.0022964* **	**-0.0039912*** **
Relative GVA per capita in 1999	(0.0004587)	(0.0005442)
	-0.1636235* **	**-0.1660021*** **
Growth of relative road length	(0.0051534)	(0.0050384)
	-0.2716506* **	**-0.2356994*** **
Growth of relative labour force	(0.0337139)	(0.033493)
	-0.2507467* **	**-0.2688283*** **
Growth of relative human capital	(0.0189286)	(0.0187325)
Number of observations	**352**	**341**
R^2	**0.7713**	**0.7898**

Note: Standard errors are shown in parenthesis under the coefficients. ***, ** and * indicate significance at 1%, 5% and 10%, respectively. The R^2 statistic indicates the overall significance of the model.

Source: Eurostat New Cronos and OECD databases (various years)

The OLS multiple linear regressions for all of the CEE administrative units (1) and CEE non-capital regions (2) show a strong (1% level of significance) negative relationship between the growth of relative GVA per capita and the growth of road length, percentage of workers with tertiary education, and migration relative to country means. These results comply with the Barro and Sala-i-Martin' postulates that "poor economies tend to grow faster than rich ones, which corresponds to $\beta > 0$"[15], and that "the migration of workers [proxied by the "labour force" variable – *the Author*] who quicken the process of convergence by moving to areas with higher capital-to-employee ratio[16]". That is, new roads help workers migrate to areas with higher capital-to-employee ratio, thereby, curbing the growth of real GVA per capita.

Both models have jointly significant regressors and strong explanatory power (0.7713 and 0.7898). There are no unobserved characteristics and measurement errors as all observed variables are true. No lags of the dependent variable are among its regressors. Therefore, regressors and residuals are not correlated and the OLS estimators are consistent.

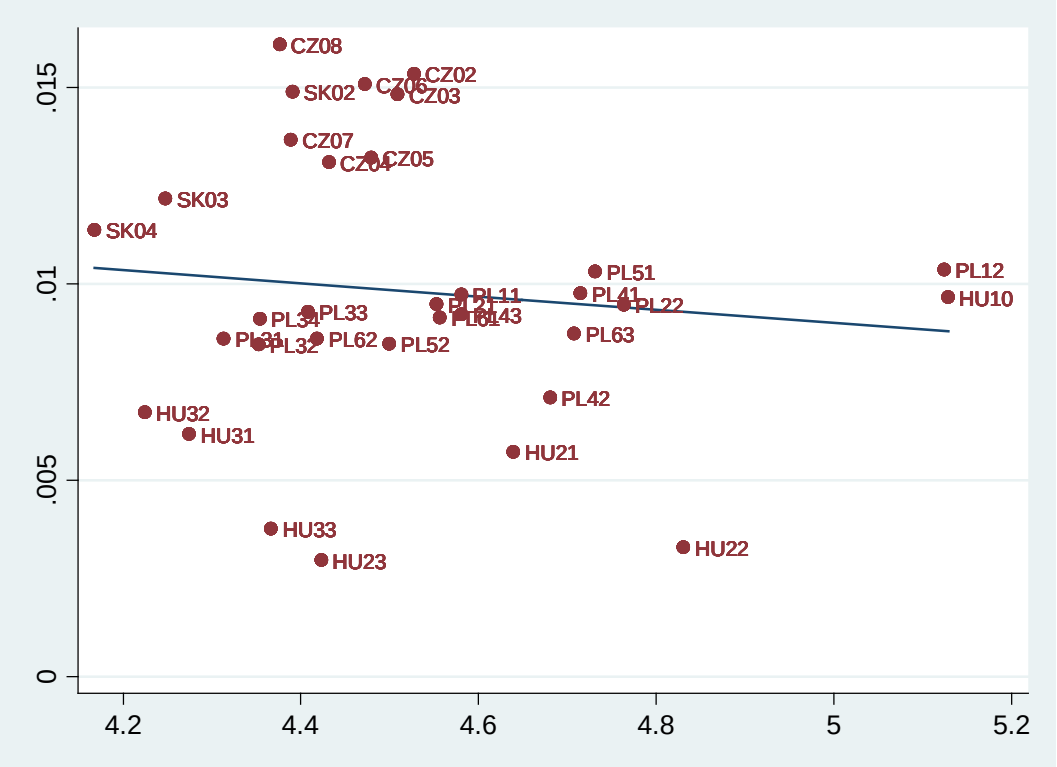
Administrative units comprised of both capitals and regions diverge slower than the regions only. The same applies to the growth of road length and human capital. The only exception is that net influx of labour force to administrative unit has lower impact on regional divergence than on national one. All these developments suggest that in regions (mostly remote and disconnected from economic density), workers have less opportunities to use migration as a means to achieve higher level of wealth.

To visualize the findings, figure 1 shows the pattern of beta-convergence of real per capita GVA across 8 Czech, 7 Hungarian, 16 Polish and 4 Slovak administrative units measured relative to their respective country means from 1999 to 2006.

Graph 8. Convergence of Gross Value Added, administrative units relative to country means: log of 1996 per capita GVA and GVA growth from 1999 to 2006

[15] Barro R.J., Sala-i-Martin X.X., 'Convergence'. Journal of Political Economy, UChicago Press 1992, p. 227
[16] Barro R.J., 'Economic growth in a cross-section of countries'. The Quarterly Journal of Economics, The MIT Press 1991, pp. 407

Growth rate of relative per capita GVA, 1999-2006

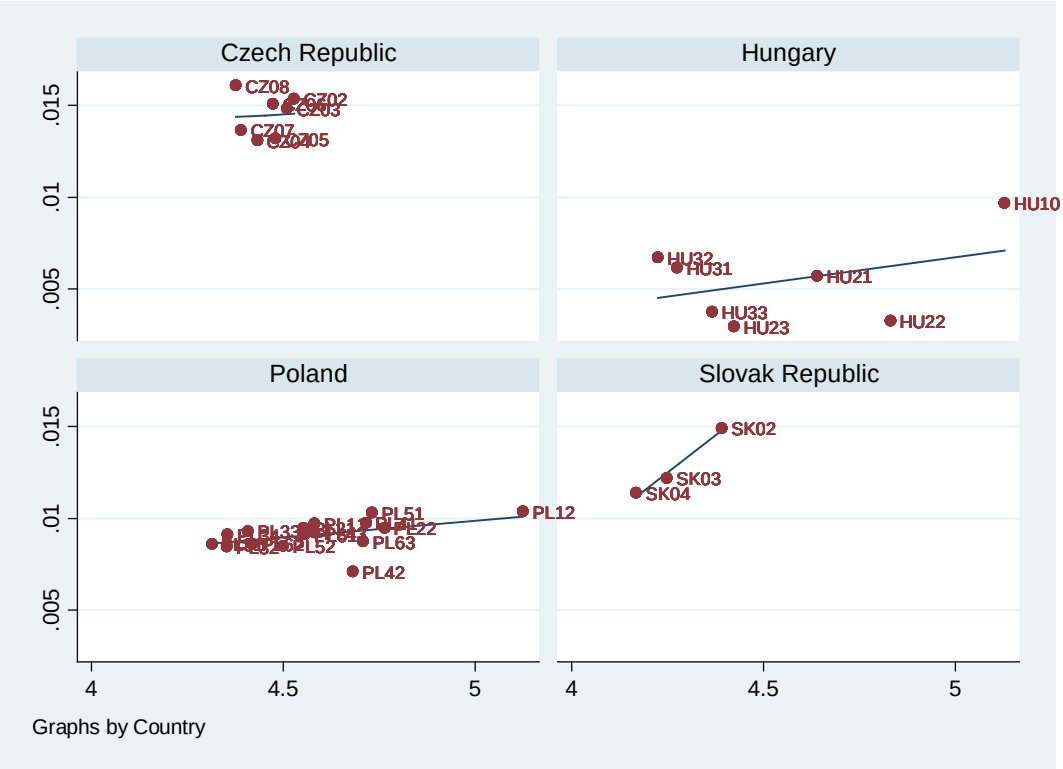


Log of 1999 relative per capita GVA

The relationship between the two variables seems to be clustered by country. Therefore, it makes more sense to plot the variables on a national basis. Thus, Figure 2 gives more detailed analysis of beta-convergences by country.

Graph 9. Convergence of Gross Value Added, administrative units relative to country means: log of 1999 per capita GVA and GVA growth from 1999 to 2006

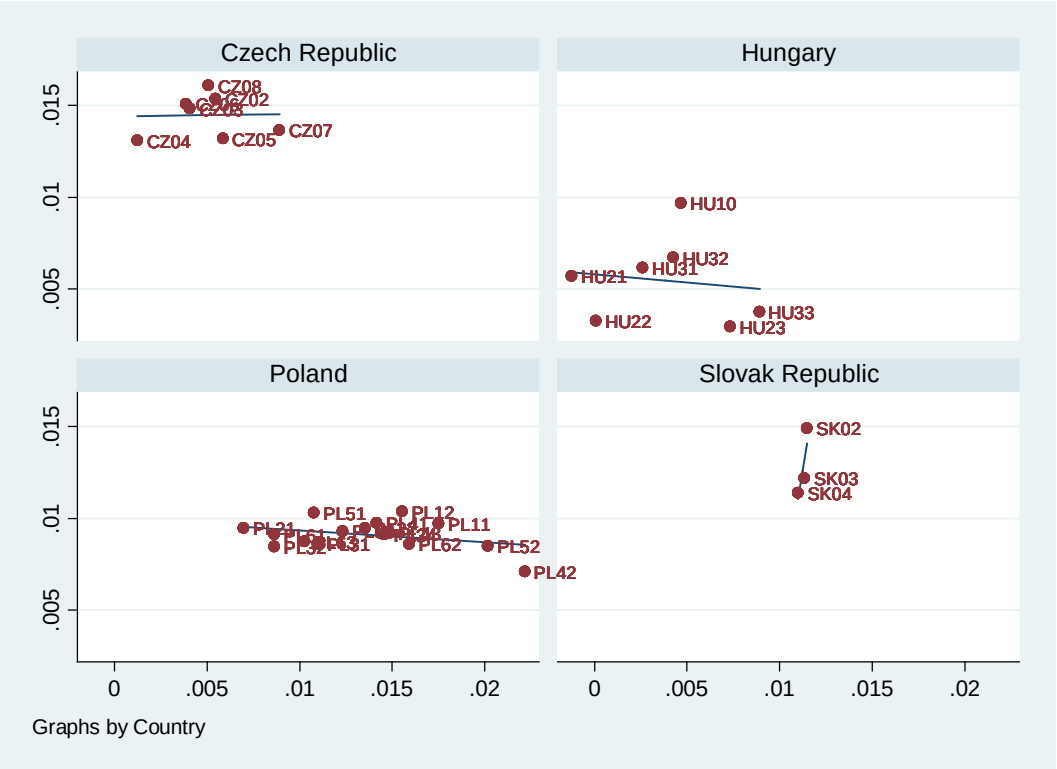
Growth rate of relative per capita GVA, 1999-2006



Contrary to the expected, more developed regions – Kosep-Magyarorszag, Mazowiecke and Zapadne Slovensko – have higher growth despite already having high relative real GVA per head in 1999. All four nations exhibit some form of divergence. While the administrative units of the four CEE states appear to be converging among each other, slowly forming a 'convergence club', on a national level, they are diverging.

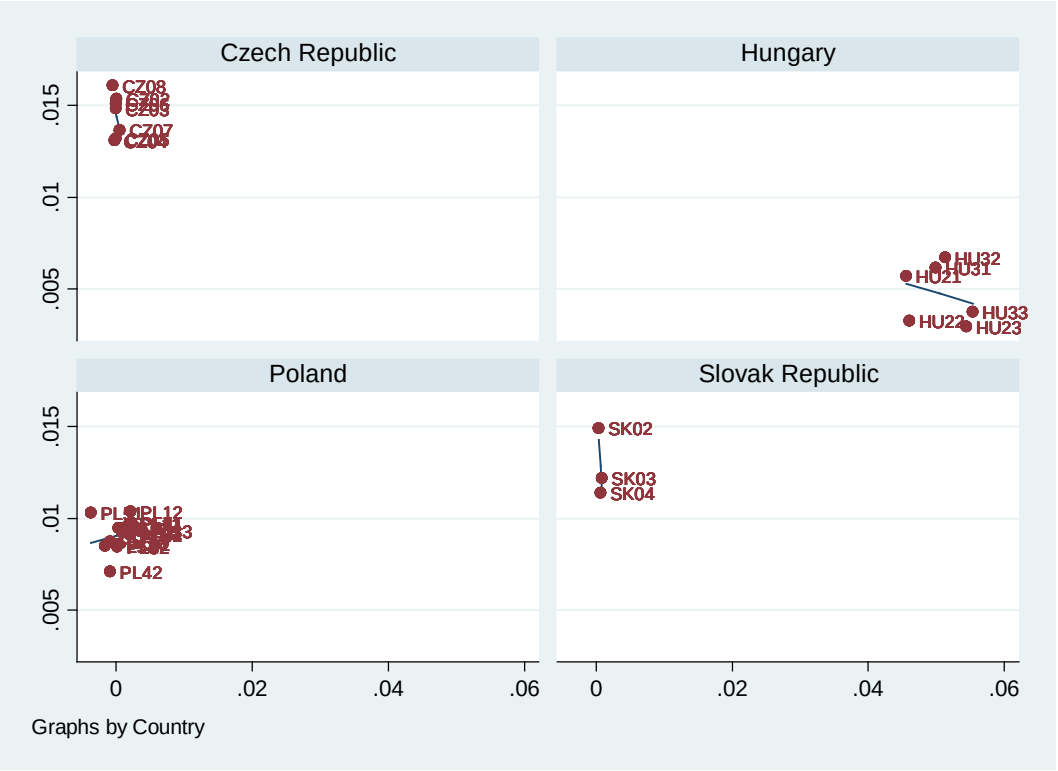
The relationship between the growth rates of relative real regional GVA per capita and relative regional human capital is steady in the Czech Republic, negative in Hungary and Poland, and strongly positive in the Slovak Republics.

Graph 10. Scatter plot of the growth rates of relative real regional GVA per capita and human capital, by country



The relationship between the growth rates of real GVA per capita and the relative length of roads is positive in Poland, and negative in Hungary and very negative in the Czech and Slovak Republics.

Graph 11. Scatter plot of the growth rates of GVA per capita and the length of roads on a national level



The relationship between the growth rates of GVA per capita and labour force is quite steady in the Czech Republic and Poland, and positive in Hungary and the Slovak Republic

Graph 12. Scatter plot of the growth rates of relative real GVA per capita and the relative labour force on a national level

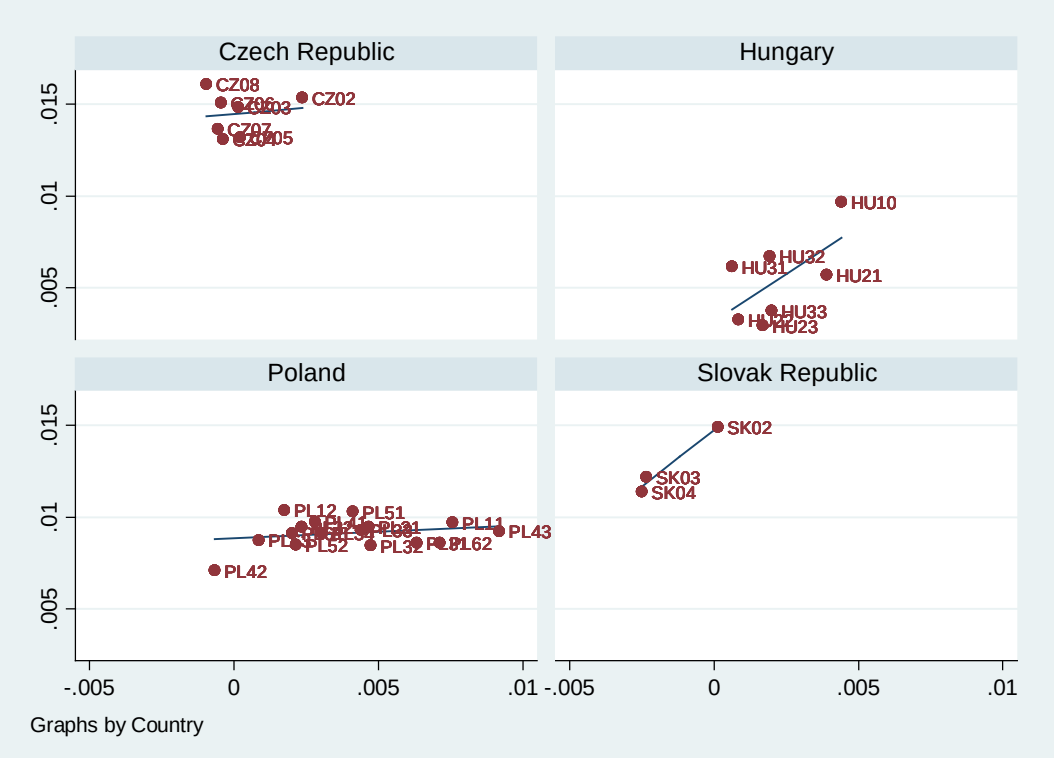


Table 4 shows the decomposition of an administrative unit *i*'s per capita GVA into eight standard sectors: public administration, financial intermediation/real estate, services, trade, construction, mining and agriculture. Services, industry and mining constitute the three largest sectors of a given economy (except for Poland, where trade is larger than mining).

Table 5. Sector shares in GVA (percent)

Sector	*Year*	*Czech Republic*	*Hungary*	*Poland*	*Slovak Republic*
Public adm.	1996	8.006676	11.62069	10.44525	8.500924
FIRE	1996	6.986439	8.867449	5.870866	7.843662
Services	1996	26.31796	30.37442	30.79873	29.01145
Trade	1996	11.32467	9.886739	14.48237	12.66647
Construction	1996	4.288979	2.177744	3.289625	3.807123
Industry	1996	22.38421	16.80331	16.67919	19.59057
Mining	1996	18.09543	14.62502	13.38962	15.78371
Agriculture	1996	2.595637	5.644617	5.044355	2.79609
Public adm.	2006	8.719554	12.15412	10.36572	8.168815
FIRE	2006	7.155552	9.261242	8.517689	8.168815
Services	2006	28.18105	30.57943	33.07586	29.60917
Trade	2006	12.30585	9.164181	14.19263	12.3843
Construction	2006	3.270499	2.662553	3.125876	4.066135
Industry	2006	21.0863	17.79938	15.60733	19.44915
Mining	2006	17.81574	15.13696	12.48159	15.38285
Agriculture	2006	1.465456	3.242142	2.633308	1.883766

Public administration:	Public administration and defence, compulsory social security; education; health and social work; other community, social and personal service activities; private households with employed persons
FIRE:	Financial intermediation; real estate, renting and business activities
Services:	Services (excluding extra-territorial organizations and bodies)
Trade:	Wholesale and retail trade, repair of motor vehicles, motorcycles and personal and household goods; hotels and restaurants; transport, storage and communication
Mining:	Mining and quarrying; electricity, gas and water supply
Agriculture:	Agriculture, hunting, forestry and fishing

The share of relative real GVA per capita generating from the economic sector of public administration rose in the Czech Republic and Hungary, but fell in Poland and the Slovak Republic. FIRE and, especially, services had their contribution to GVA increased in all four countries. The share of GVA from trade rose everywhere, except for the Czech Republic. The portion of construction rose only in Hungary and the Slovak Republic. The share of industry fell in the Czech Republic, Poland and the Slovak Republic (albeit slightly). The part of mining decreased in the Czech Repubic and Poland, rose in Hungary and (slightly) decreased in the

Slovak Republic. The portion of agriculture dwindled in all four economies. All in all, we can observe the process of reallocation of productive capital from one group of economic sectors, like agriculture, industry and mining, to another – trade, financial intermediation and real estate. Thus, the four CEE states are heading to the post-industrial structure of their economies.

Table 5 shows sector productivity in 1996, 2006 and the growth between these two years. We can see that in the Czech Republic, construction, industry, mining and agriculture exhibited negative growth. In the Slovak Republic, only industry and mining had stagnated by the end of the period. Hungary and Poland represent contrasting examples: the former country showed productivity growth in all the sectors of the economy, whereas the latter one showed decline in productivity in all sectors (except for the financial intermediation/real estate).

Table 6. Log of sector productivity and its growth

Sector	*Year*	*Czech Republic*	*Hungary*	*Poland*[i]	*Slovak Republic*
Growth of sectoral productivity:					
- Public	1996 (/98) – 2006	.0040498	.0039705	-.0011984	.0049652
- FIRE	1996 (/98) – 2006	.007763	.0083014	.0050246	.0203993
- Services	1996 (/98) – 2006	.0048508	.0043559	-.0008615	.0063246
- Trade	1996 (/98) – 2006	.0077594	.0053604	-.0039355	.006804
- Construction	1996 (/98) – 2006	-.0308607	.0110034	-.0244685	.
- Industry	1996 (/98) – 2006	-.0093802	.0034777	-.0063821	-.0076702
- Mining	1996 (/98) – 2006	-.0089858	.0036641	-.0061398	-.0117006
- Agriculture	1996 (/98) – 2006	-.0062909	.7566215	-.0670388	.0242731
Log of sectoral productivity:					
- Public	1996 (/98)	1.632906	1.701733	2.11975	1.483012
- FIRE	1996 (/98)	1.444558	1.415441	1.812452	1.391872
- Services	1996 (/98)	2.813913	2.660608	3.289544	2.708549
- Trade	1996 (/98)	1.973967	1.537885	2.505184	1.879476
- Construction	1996 (/98)	1.006893	.0301654	1.129479	.6727378
- Industry	1996 (/98)	2.643766	2.056039	2.65125	2.307708
- Mining	1996 (/98)	2.419481	1.91116	2.402845	2.089495
- Agriculture	1996 (/98)	.1581277	.7845938	1.088146	.2248731
Log of sectoral productivity:					
- Public	2006	1.686523	1.793363	2.096996	1.441239
- FIRE	2006	1.430528	1.510149	1.896081	1.509579
- Services	2006	2.852315	2.721457	3.264126	2.718669
- Trade	2006	2.02628	1.51455	2.417836	1.851794
- Construction	2006	.7018789	.2781997	.9037532	.7118182

- Industry	2006	2.53844	2.157582	2.502795	2.272875
- Mining	2006	2.356521	1.981391	2.273283	2.028278
- Agriculture	2006	-.3682425	.2194612	.5827191	-.1899779

i. Poland does not have observations for the 'labour force' variable and, consequently, for the contribution of sectors to GVA per worker for 1996, but only starting from 1998.

Table 6 below shows sectoral breakdown of national employment in the four CEE states. In the Czech Republic, labour force had flown from the same sectors that had negative productivity growth. In Hungary, the share of workers employed in industry and agriculture had decreased by 2006. Sectoral employment in the Polish economy followed the same development path as the Czech Republic did. In the Slovak Republic, part of human resources moved from industry, agriculture and public administration to financial intermediation/real estate, services, trade and construction. The common feature of the four CEE states is that the share of persons employed in industry and agriculture relative to labour force in other sectors of economy was higher in 1999 (or in 2000 in the case of Poland and the Slovak Republic) than in 2006. It is needless to mention that these very sectors have negative growth of productivity relative to the other sectors. The ingenious market appears to be directing the labour resources to the more efficient sectors!

Table 7. Sector shares in employment (percent)

Sector	*Year*	*Czech Republic*	*Hungary*	*Poland*[i]	*Slovak Republic*[i]
Growth of sectoral share of employment:					
- Public	1999 (/00) – 2006	.0083918	.0018005	.0044374	-.0087625
- FIRE	1999 (/00) – 2006	.0142747	.0289258	.0267098	.0349608
- Services	1999 (/00) – 2006	.0030613	.0049651	.0051345	.0013724
- Trade	1999 (/00) – 2006	-.0053526	.0021558	-.0004343	.0017081
- Construction	1999 (/00) – 2006	-.1199831	.025337	-.0219505	.0290998
- Industry	1999 (/00) – 2006	-.0025879	-.0159401	-.0039069	-.0036747
- Agriculture	1999 (/00) – 2006	-.0411265	-.0443918	-.0154091	-.0583711
Sectoral shares in employment:					
- Public	1999 (/00)	.1411169	.1651744	.1497834	.1727915
- FIRE	1999 (/00)	.0471872	.0365994	.0390835	.0438924
- Services	1999 (/00)	.349448	.3586592	.3335552	.3669147
- Trade	1999 (/00)	.1611558	.1568644	.1446848	.1503065
- Construction	1999 (/00)	.1611558	.0424983	.0476854	.0493826

- Industry	1999 (/00)	.2057588	.1889052	.1562278	.1776595
- Agriculture	1999 (/00)	.0339872	.0512992	.1289799	.0390527
Sectoral shares in employment:					
- Public	2006	.1508737	.1675686	.1544983	.1624675
- FIRE	2006	.0528529	.0459776	.0470032	.0558286
- Services	2006	.3580983	.3731555	.3457299	.3704541
- Trade	2006	.1543829	.1595902	.1442455	.1521129
- Construction	2006	.0579661	.0519164	.0408236	.0603638
- Industry	2006	.2015373	.1661178	.152005	.1731396
- Agriculture	2006	.0242888	.0356738	.1156945	.0256336

i. Both Poland and the Slovak Republic have observations for relative sectoral shares in employment and, consequently, for the growth of relative sectoral share of employment only starting from 2000.

6. Conclusion

Although the examined period is relatively short (9 years of balanced data set), the findings support the hypothesis that new roads help workers migrate to areas with higher capital-to-employee ratio, thereby, putting a cap on the growth of real GVA per capita. In regions (mostly remote and disconnected from economic density), workers have less opportunities to use migration as a means to achieve higher level of wealth.

While the administrative units of the four CEE states appear to be converging among each other, slowly forming a 'convergence club', on a national level, they showed divergence from 1999 to 2006. The Slovak Republic is the only country to show steady convergence at the well-known Sala-i-Martin's "2 percent".

Changing pattern of sectoral share of GVA per worker suggests the process of the reallocation of productive capital from one group of economic sectors, like agriculture, industry and mining, to another – trade, financial intermediation and real estate. Thus, the four CEE states are heading to the post-industrial structure of their economies. Besides, the common feature of the four CEE states is that the share of persons employed in industry and agriculture relative to the labour force in other sectors of economy had declined by 2006. The same sectors had negative growth of productivity relative to the other sectors. Instead, the sectors with higher growth of productivity relative to the other parts of economy increased the share of employees working for "this" particular sector.

Nevertheless, the findings and model should not be overestimated as there could have been a measurement error. The nominal values of gross value added of each region were deflated by the national GDP deflator – instead of unavailable deflators for individual administrative units. If relative purchasing power parity was unequal across the administrative units, then the growth rates of relative real GVA per capita could have been measured incorrectly. Moreover, physical indicators are not very good proxies for infrastructure, mostly because much of resources are spent on maintaining roads rather than expanding them.

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9. Annex

OLS linear multiple regression:

```
. reg lgrowth  loutputlag lhumklag llabourlag dummy lopexlag
```

Source	SS	df	MS	Number of obs =	93
				F(5, 87) =	3.78
Model	.010333317	5	.002066663	Prob > F =	0.0038
Residual	.04760678	87	.000547204	R-squared =	0.1783
				Adj R-squared =	0.1311
Total	.057940096	92	.000629784	Root MSE =	.02339

lgrowth	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
loutputlag	-.0563794	.0200782	-2.81	0.006	-.0962869	-.0164719
lhumklag	.0800742	.0256797	3.12	0.002	.029033	.1311153
llabourlag	.0104568	.0084784	1.23	0.221	-.0063949	.0273086
dummy	-.0108145	.0061903	-1.75	0.084	-.0231183	.0014894
lopexlag	.0117194	.0055302	2.12	0.037	.0007275	.0227112
_cons	.3437892	.1998925	1.72	0.089	-.0535187	.7410971

```
. reg lgrowth  loutputlag lhumklag llabourlag dummy lcapexlag
```

Source	SS	df	MS	Number of obs =	94
				F(5, 88) =	3.75
Model	.010242278	5	.002048456	Prob > F =	0.0040
Residual	.048060951	88	.000546147	R-squared =	0.1757
				Adj R-squared =	0.1288
Total	.05830323	93	.000626916	Root MSE =	.02337

lgrowth	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
loutputlag	-.0583566	.0208434	-2.80	0.006	-.0997785	-.0169347
lhumklag	.0569313	.0265548	2.14	0.035	.0041593	.1097033
llabourlag	.0035292	.0101347	0.35	0.728	-.0166113	.0236698
dummy	-.0057082	.0057021	-1.00	0.320	-.0170399	.0056234
lcapexlag	.0167894	.0075331	2.23	0.028	.0018189	.03176
_cons	.4290989	.2290741	1.87	0.064	-.0261377	.8843356