Regional Competitiveness in Central Europe:

The Importance of Transport Infrastructure Development

by

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Abstract

The topic of regional competitiveness has gained tremendous importance over the last decade. As regions are increasingly being recognized as drivers of economic growth, both academics and policy-makers are trying to identify the key factors which would make the regions more competitive. While transport infrastructure is only one of the factors influencing regional competitiveness, it usually requires the largest amount of public investments. The topic is particularly relevant in the context of the European Union, as reduction of regional disparities remains a challenge, especially for the transition countries of Central Europe.

This paper has analyzed how the development of transport infrastructure contributed to increasing the regional growth and competitiveness in Central Europe. In particular, the multivariate linear regression analysis has been conducted, using secondary data on 37 NUTS 2 regions of Central Europe, over the 2000-2009 period. The analysis demonstrates that the development of transport infrastructure is strongly and positively associated with the growth of regional competitiveness, measured in terms of GDP per capita. Furthermore, the paper notes that the positive effect of the infrastructure investments is larger in regions applying complementing policies (in particular innovation), but concludes that a more integrated approach to development policies would be beneficial.

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Introduction

The topic of regional competitiveness has gained importance during the recent years, both among academics and policy-makers. Regions are increasingly being recognized as drivers of economic growth; however, the specific policies which would increase their competitiveness are not easily identified. The topic is particularly relevant in the European Union (EU) context, as reduction of regional disparities remains a challenge, especially for the new member states. While some authors argue there should be a common, universal approach to regional development (Gill 2010), others call for the development of specific, place-based policies (Barca 2009). The place-based strategy is a characteristic of the EU approach; European policy-makers believe that the lagging regions should be targeted with specifically tailored policies to increase growth (Barca 2009, 5).

There is no particular theoretical perspective that would capture the complexity of regional competitiveness (Kitson, Martin and Tyler 2004; Cambridge Econometrics and Ecorys 2003). Broadly, the concept of regional competitiveness can be viewed as a set of determinants enabling region's long-term prosperity (Kitson, Martin and Tyler 2004), increasing productivity, employment and standard of living. While there are numerous approaches aiming to identify the common determinants that affect the level of regional competitiveness, the majority of theoretical frameworks revolve around three broad themes: infrastructure and accessibility, human resources, and innovation and research and development activities (Cambridge Econometrics and Ecorys 2003, 1-1, 2-32).

The available empirical research is consistent with these three main themes. The research conducted in OECD countries demonstrates that, for instance, infrastructure investments are a necessary ingredient for regional growth, but need to be complemented with innovation and human resources policies (OECD, 2009a). Similar conclusions have been made in EU countries as well; most recent research shows that more developed regions are more competitive, because they are characterized by innovation, better training and better infrastructure (European Commission 2010a).

The development of transport infrastructure is therefore only one of the factors influencing the regional competitiveness, but typically requires a large amount of financial resources. For example, transport infrastructure investments account for the largest portion (22%) of the current EU's cohesion policy budget (European Commission 2008, 3). While such a high figure illustrates the large needs of the European regions, it also highlights the relevance of infrastructure investments to increase the regional competitiveness. The countries in the largest need of such public investments, both from cohesion budgets as well as other sources of financing, are particularly the new member states, especially in the regions of Central Europe (CE). During the 2000-2009 period, approximately 35 billion Euros were invested into the road and rail infrastructure of the CE region (International Transport Forum), with the objective to provide the transport infrastructure comparable to European standards.

However, the impact of these investments in this particular area has not received much attention so far. Most of the existing research has focused on the most developed European and OECD countries, highlighting the importance of infrastructure investments. Even though CE countries have been a part of such analyses (OECD 2009a), these broad conclusions lack specific geographical or historical context. Therefore, they cannot be readily used for development of specific policies to increase the competitiveness of regional economies, especially keeping in mind the specific, place-based strategies. This paper should therefore offer a more detailed insight into the specific characteristics of the regional economies of Central Europe, to be considered when designing the development policies.

In particular, this paper will analyse to what extent the development of transport infrastructure had an impact on the regional competitiveness in Central Europe over the last decade. Furthermore, the paper will explore whether the potential impact of these investments was strengthened by complementing policies, such as investments into innovation activities and human resources. The aim of this paper is to examine the context-specific link between infrastructure investments and regional competitiveness, which would serve as a basis for policy recommendations, with the objective to further increase the regional competitiveness.

More specifically, the analysis will focus on 37 regions of Poland, Czech Republic, Slovak Republic, Hungary and Slovenia. Using the secondary data collected from the regional statistical databases (Eurostat and OECD regional statistics database), the data is analysed using quantitative methods, relying on the multivariate linear regression analysis. The operationalization of key variables relies on the existing theoretical and research approaches ("regional competitiveness hat", Cambridge Econometrics and Ecorys 2003). The regional GDP per capita is used as a key measure of competitiveness, which is complemented by the employment rate. The key explanatory variables are the availability of infrastructure, as well as innovation activities and human resources.

This analysis appears to demonstrate that infrastructure investments contributed to the increased competitiveness in regions of Central Europe. More interestingly, they were a necessary, but also a sufficient ingredient to increase the regional competitiveness. Furthermore, the ability of infrastructure development to improve the regional growth and competitiveness was positively influenced by complementary policies, promoting education and innovation. The development of motorway network has had the greatest impact on regional GDP, which is larger in regions with higher investments into research and development. The paper concludes, however, that these impacts could be even stronger with more balanced policies.

The paper is structured in three main chapters. The first chapter outlines the theoretical and empirical framework of determinants of regional competitiveness, which shape the overall methodology of the paper. The second chapter describes the growth of regional GDP in Central Europe during the last decade, as a key indicator of regional competitiveness. The chapter also presents the development of transport infrastructure in observed regions, as well as other development policies (education and innovation). These data serve as a basis for the quantitative analysis in the third chapter. Multivariate linear regression is used to analyze the link between the development of infrastructure and regional competitiveness. Based on the analysis, the paper will identify the main policy recommendations, to further increase the competitiveness of regional economies in Central Europe.

Chapter 1: Theoretical framework and research methodology

This chapter will define the complex notion of regional competitiveness. It will also outline the key determinants of regional competitiveness, as described in the literature and tested in broad empirical research. These frameworks shape the research methodology of this paper, described at the end of the chapter.

1.1. Definition and relevance of competitiveness

The notion of competitiveness is the focus of many discussions on the international policy agenda. In particular, the international community has been focusing on measurement of competitiveness, as well as design of policies which would increase the competitiveness of national or regional economies. In the European Union (EU), the notion of competitiveness has a prominent role in terms of its growth objectives. The key objective of the Lisbon Strategy in 2000 was to make the EU "the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion" (Euractiv 2004). The ambitious objectives continue throughout the Europe 2020 agenda; it aims for smart, sustainable and inclusive growth, focusing on promotion of a "more competitive economy" as one of the priorities (European Commission 2010b).

However, there is no single definition of competitiveness. Traditionally, the economic theory has questioned its relevance. For some authors (Krugman 1996, Porter 1992), competitiveness is equal to productivity, i.e. the value of the goods and services produced by a nation per worker. Over the last decade, however, the literature recognized competitiveness as a broader term. It is now seen to incorporate a wide set of external factors that enable higher productivity to the companies located in a certain territory (Kitson, Martin and Tyler 2004, Porter 2003, Camagni 2002). For example, World Economic Forum defines national competitiveness as a "set of institutions, policies, and factors that determine the level of productivity of a country" (World Economic Forum 2011, 4).

Regional competitiveness receives increased attention in recent years, as regions are being increasingly perceived as generators of economic growth. However, since regions are between the macroeconomic (national) and microeconomic (company) perspective, this adds an additional layer of complexity to defining the regional competitiveness. A broad definition is given by the European Commission (1999), defining it as a range of common regional characteristics which affect the competitiveness of all companies in that location. The combination of these factors – such as quality of labor force, public infrastructure, presence of innovations, cultural and institutional characteristics – provides a productive base for a regional economy (Kitson, Martin and Tyler 2004, 994). Consequently, competitive regions are able to attract successful firms which will generate economic growth, while maintaining or increasing the standards of living (Huggins and Thompson 2010). To conclude, the idea of regional competitiveness should be understood beyond the traditional, narrow concept of productivity. Instead, regional competitiveness is a result of a wide variety of factors which provide the region with a certain growth potential; ultimately, competitive regions will be able to increase economic prosperity of the population.

The lack of a single definition of competitiveness reflects its complexity and multidimensionality. This is also demonstrated in the attempts to measure the levels of competitiveness, both on the national and the regional level. For example, the World Economic Forum's Global Competitiveness Index (GCI) is a composite measure of twelve different factors influencing the overall national competitiveness[1]. Similarly, European

[1] Global Competitiveness Index relies on twelve pillars: institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labor market

Regional Competitiveness Index (RCI), designed in 2010, measures and ranks the competitiveness of all European regions (Annoni and Kozovska 2010). This is also a composite index, relying on eleven pillars and capturing a wide range of characteristics, including innovation, institutions, infrastructure and measures of health and human capital. The officials of United Kingdom are also observing the performance of UK regions since 2000 through UK competitiveness index (Huggins and Thompson 2010). These composite indices have different approaches to measuring competitiveness, but a common objective: measuring competitiveness can assist in identifying the factors which are constraining to economic growth. Once the weaknesses are identified, this information can be used to prioritize and target the government interventions.

In particular, public investments are a crucial government tool for increasing the regional competitiveness. In the European Union, approximately two-thirds of all public investments are carried out by regional or local governments (European Commission 2010, 157), illustrating the importance of regions and their competitiveness to generate economic growth. A large portion of public investments in the less developed regions is supported by the cohesion policy funds, which are to a large extent directed to construction and rehabilitation of the transport infrastructure networks. However, as will be presented in the next section, transport infrastructure is only one of the factors influencing the regional competitiveness.

1.2. Determinants of regional competitiveness

The previous section has demonstrated that there is no single universally accepted definition of competitiveness. Nonetheless, it is understood that regional competitiveness is a result of multiple factors; it resides in the productivity of individual companies, but is strongly

efficiency, financial market development, technological readiness, market size, business sophistication, and innovation.

influenced by a wide range of economic, institutional and social characteristics. There has been significant theoretical and empirical research conducted on the topic, including specifically the regional level.

More broadly, the theoretical debate regarding the optimal design of the regional development policies revolves between the universal and specific approach to regional development. On one hand, some authors (Gill 2010) argue that government interventions can be universally applied to most of the regions. In this view, regional development policies rely on agglomerations, recognizing that some regions will remain undeveloped. Such approach relies on "spatially blind policies" (OECD 2011a, 176), underlining the relevance of strong institutions and infrastructure, which will link the agglomerations with less developed areas. Government interventions are then to be used only in rare occasions. On the other hand, other authors (Barca 2009, OECD 2009a) call for the development of specific, place-base policies. They believe that each region has development potential, which can be realized by specifically tailored government policies to increase growth (Barca 2009, 5). The approach of place-based policies is accepted by the EU officials, as well as the OECD, as the new paradigm of regional policy (OECD 2011a, 34). It relies on a holistic approach to regional development. Regional competitiveness, in this view, can be improved by a mix of "soft" and "hard" investments: capital stock, labor market, business environment, and social capital (OECD 2009b, 51).

This debate is illustrative of the different views in the literature regarding the key best approach to increasing the regional competitiveness; both academics and policy practitioners are trying to identify the key factors which can increase the economic growth[2]. While regional competitiveness depends on a wide variety of characteristics (illustrated by composite

[2] Detailed literature review of economic growth theories, as well as determinants of national and regional competitiveness has been presented by Cambridge Econometrics and Ecorys, 2003.

measures of competitiveness), most of the views revolve around several recurring factors. In general, the key determinants of regional competitiveness can be grouped under three broad categories: (i) basic infrastructure and accessibility; (ii) human resources; and (iii) productive environment (Cambridge Econometrics and Ecorys 2003, 1-1). Table 1 below presents the overview of key factors of regional competitiveness, under this main categorization.

Table 1: Overview of Key Factors of Regional Competitiveness

Infrastructure and accessibility	Human resources	Productive environment
Basic infrastructure (road, rail, air, property) Technological infrastructure (ICT, telecom, internet) Quality of location (housing, safety)	High-skilled workforce Demographic trends (migration of skilled workers)	Innovation (patents, R&D levels, research institutes) Institutional capacity Entrepreneurial culture Sectoral concentration Internationalization (exports, investments, FDI)

Source: Adapted from Cambridge Econometrics and Ecorys 2003, page 2-32

The empirical research confirms that regional competitiveness is a combination of multiple factors, even though the findings are fairly diverse. For example, the econometric analysis of OECD countries in the period between 1995 and 2005 (OECD 2009b) relies on three key determinants: physical capital, human capital and innovation. The analysis reveals that human capital and innovation have a positive impact on the regional economic growth. Furthermore, infrastructure investments do not directly increase regional economic growth. The effects of infrastructure are positive when combined with education and innovations, explained by the fact that the lack of high-skilled workers and innovation activities cannot stimulate growth (OECD 2009a, 42). Additional analysis recognized the time lag between the investments and their impact; infrastructure and human capital investments require three years, and innovation takes five years to influence growth (OECD 2009b).

Similar conclusions have been made in EU countries as well. The econometric analysis of the EU-15 regions during the 1980-2001 period (Cambridge Econometrics and Ecorys 2003) has established a positive relationship between innovation (R&D) activities and economic growth. However, the impact of human capital and physical infrastructure was not able to be assessed, due to the limited availability of regional data at the time.

The most recent analysis of EU-27 countries, as part of the European Commission's Fifth Report on Economic, Social and Territorial Cohesion (2010a), highlights that more developed regions are more competitive. The high performing regions are characterized by advanced innovation, education, infrastructure and institutions. The report highlights the regional disparities across the European area, concluding that the relative importance of particular factors varies in different regions, depending on the population density, urbanization and a wide range of other characteristics.

These empirical findings show that the most competitive regions are successful as a result of multiple factors, demonstrating the need for coordinated policies at the regional level. OECD (2009a) warns that lack of such approach would result in a failure; the investments only in human capital without a corresponding availability of employment opportunities may cause brain drain, while the infrastructure investments will remain unutilized and will not be able to generate growth without complementing policies.

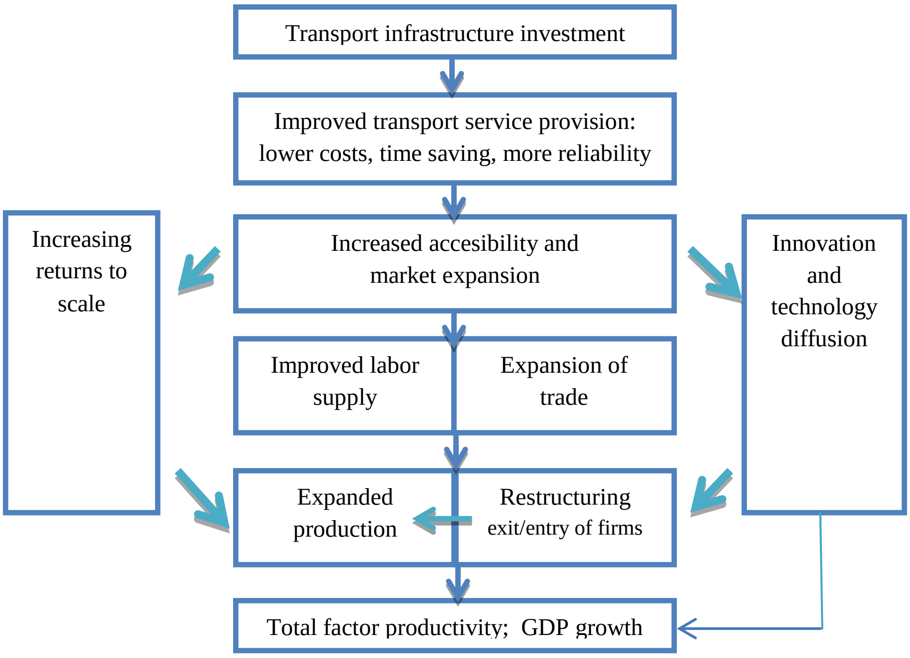
1.3. Infrastructure investments: one of key determinants of regional competitiveness

The development of transport infrastructure is one of the factors influencing regional competitiveness. However, the investments into development of transport infrastructure typically require a significant amount of financial resources. For example, transport infrastructure investments account for the largest portion of the current EU's cohesion policy budget (European Commission 2008). Therefore, it is of crucial importance to ensure that the regions are able to capture the benefits of the infrastructure development, through complementing policies.

The development of infrastructure can contribute to competitiveness of a region by improving its accessibility, employment and efficiency (OECD 2002). Infrastructure investments have a direct impact on improving the travel conditions, by reducing the travel time and increasing safety. However, there are also many additional indirect benefits that should be noted[3]. The reduction of travel time improves the accessibility of the region, increasing the size of available labor and production market. Larger accessibility can also create employment opportunities for domestic or neighboring regions, while the activities related to construction and maintenance of transport infrastructure can also create employment. Moreover, better accessibility creates higher competition in industry and labor markets, due to easier inflow of goods and workers. In turn, higher competition facilitates improved production and increased efficiencies within the companies, as well as on the labor market. In summary, transport infrastructure can improve market access, reduce production costs, improve business and labor productivity, and ultimately increase overall competitiveness and growth of the region (OECD 2002, 23). Figure 1 presents the impacts of infrastructure investments on economic growth in a schematic way.

[3] OECD's 2009 report How Regions Grow provides an overview of the economic growth theories (pages 70-79), while ESPON (2011, pages 52-53) offer a more detailed review of theoretical approaches regarding the impacts of transport infrastructure on regional development.

Figure 1: Transport infrastructure investments and effects on economic growth



Source: OECD: Regions Matter, 2009, page 56

However, the development of transport infrastructure does not automatically generate regional growth. Even though improved transport infrastructure does create growth opportunities, it can also have a negative impact on a particular region (OECD 2002, 9). The less productive companies can lose their market shares due to competition, while improved connections can increase the migrations and negatively impact the regional labor markets. Therefore, the less developed regions can actually lose their resources and experience a reduction of economic activity, known as the so-called *leaking by linking* phenomenon (European Commission 2010a, xx). The potential negative regional impact can be avoided through careful design of complementing policies. The impact of the infrastructure development depends on the ability of the region to use it in an efficient way, as well as availability of other factors, such as human capital and innovation (European Commission 2010a, 56).

While there is a broad range of theoretical literature analyzing the potential impact of infrastructure investments on economic growth, the empirical evidence is limited. As previously mentioned, it is difficult to establish a direct link between infrastructure investments and economic growth. Nonetheless, there have been a few studies which have attempted to isolate its impact in the European context, mostly focusing on evaluation of investments financed by structural and cohesion funds. For example, one of the first studies assessed the 1994-1999 programme in five European countries (Ireland, Portugal, Spain, Italy, Greece). The findings confirmed a positive relationship between infrastructure investments and the level of regional GDP per capita (Oscar Faber 2000); however, the authors could not establish causality of the relationship.

A recent report (AECOM and RGL Forensics 2012) has assessed the contribution and impact of the 2000-2006 ISPA and Cohesion funds on trans-European transport networks in 16 member states. The report concludes that the ability of a region to utilize the infrastructure investments for growth depends on its initial transport availability, as well as its level of development. Interestingly, the research found that the less developed member states have recorded the highest economic growth. This should be considered, though, as a cumulative impact of joining the common market, FDI inflows and the development of the transport network. Nonetheless, the report concludes that the transport investments were most beneficial to the least developed regions, as it increased their market potential, regional competitiveness and overall economic development in terms of GDP per capita (p.68).

Another model (Ecorys Nederland BV 2006) estimates the future impacts of the infrastructure investments under the 2007-2013 programming period in 15 cohesion fund-eligible countries. The study quantified the estimated impact of infrastructure investments on national economies; planned investments are expected to increase the country’s per capita income on an average of 0.5% in the long run (until year 2031). The study also estimates significant spillover effect of regional infrastructure investments to the whole country, as well as the regions in the neighboring countries (p.138).

However, all of the empirical research done so far – either on the cumulative or isolated impact of infrastructure investments - has been conducted on a large number of countries with different characteristics. The comprehensive research analyzing the effects of all OECD or EU countries tends to be dominated by the most developed and large economies, while the regional levels, especially of less developed and smaller economies, receive less attention. To my knowledge, no similar studies have been conducted at the regional level focusing on the challenges of the transition countries. Consequently, the conclusions of the empirical research cannot be easily used for policy interventions, especially using the place-based approach. This limitation of research to date is particularly relevant for the policy makers in the transition states, which are typically less endowed with quality transport links. The poor transport infrastructure constrains market access, which has a negative impact on the overall regional prosperity.

In particular, the countries and regions of Central Europe lag behind in terms of availability of infrastructure. Therefore, over the last decade, significant funds have been invested into the development and improvement of their transport networks, with the objective to improve the regional accessibility, competitiveness and growth. This paper will aim to analyze the context-specific link between these investments and the improved regional competitiveness, relying on the methodology described in the next section.

1.4. Research methodology

Given the specifics of the transition countries of Central Europe, this paper will focus on analyzing the developments in regional growth and competitiveness of Central-European regions during the last decade. More specifically, it will analyze these trends comparing it with the development of infrastructure, examining the context-specific link between infrastructure investments and regional competitiveness. The analysis will also take into account the complementing policies.

The thesis will aim to demonstrate that transport infrastructure investments are an important factor influencing competitiveness in regions of Central Europe. Therefore, two research hypotheses will be tested:

H1. Development of transport infrastructure increases the regional competitiveness in Central Europe; and

H2. The impact of infrastructure development on regional competitiveness is influenced by complementary policies, promoting education and innovation.

The analysis will focus on regions of Poland, Czech Republic, Slovak Republic, Hungary and Slovenia. In particular, the analysis will be based on 37 NUTS 2[4] regions of central Europe, during the 2000-2009 time period. The main source of data is Eurostat's Regional Statistics database, complemented with OECD's Regional Database.

The paper will use quantitative analysis to test the research hypotheses. In the first step, a simple bivariate correlation analysis will be performed, which will be followed by the

[4] The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system dividing up the economic territory of the European Union. NUTS 2 regions are considered as basic regions for application of regional policies. Source: Eurostat.

multivariate linear regression. The multivariate regression will include a number of interaction variables for testing the second hypothesis. The robustness of the findings will be tested using control variables, as well as country, region and year dummy variables. The statistical analysis will be carried out using the IBM SPSS program. Key measure of competitiveness will be GDP per capita, while the key explanatory variable will be the availability of infrastructure, in combination with human resources and innovations. The operationalization of key variables is in line with the existing theoretical approaches, which is presented in detail in Chapter 3.

Chapter 2: Characteristics of Central European regions

The aim of this chapter is to describe the variety of factors that may have influenced the regional competitiveness in Central Europe over the last decade. Following the classification of regions, the chapter will analyze the economic performance of regions as a measure of regional competitiveness. Exploring the levels of GDP per capita across regions of Central Europe, the chapter will demonstrate that growth has been achieved outside the capital or urban regions, revealing growth opportunities in different locations. The chapter will further present the trends in development of transport infrastructure, as well as human resources and innovation as factors influencing regional competitiveness. The presented data will then be used for the quantitative analysis in the following chapter.

2.1. Definition and classification of regions

A "region" can broadly be defined as an administrative unit below the national level. European Union's territory is divided into so-called NUTS regions - "Nomenclature of Statistical Territorial Units". NUTS is a hierarchical classification, distributing the territory of each member state into a number of NUTS 1 regions, which are then subdivided into NUTS 2 and NUTS 3 regions. For practical reasons, the NUTS classification corresponds to administrative classifications of the member states, in line with the geographical units. The level of the NUTS region is based on the population thresholds, as presented in Table 2.

Table 2: Population thresholds for the size of the NUTS regions

Level	Minimum	Maximum
NUTS 1	3 million	7 million
NUTS 2	800 000	3 million
NUTS 3	150 000	800 000

Source: European Regional and Urban Statistics Reference Guide, Eurostat, 2009

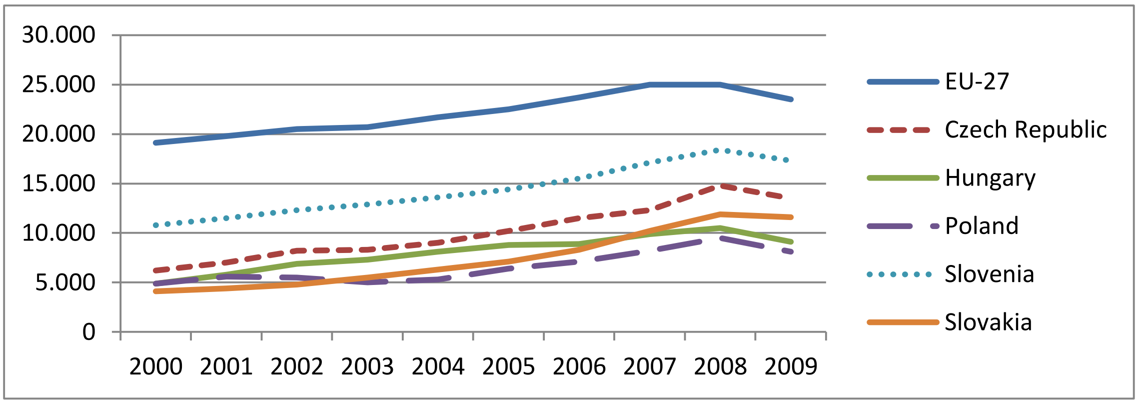
For the purposes of this paper, the definition of region corresponds to the NUTS 2 classification. With the population thresholds between 800,000 and 3 million people, NUTS 2 regions are considered to be optimal units for successful implementation of regional policies (Eurostat 2011a). Consequently, they are also basic units which are eligible for support from EU funds, as are thus used to assess the impact of cohesion policies in general. Furthermore, the NUTS 2 level is the most appropriate for regional analysis due to the availability of data, since the European statistical office (Eurostat) regularly collects and publishes the regional statistical data on NUTS 2 level. In addition, OECD's Regional Database is also a valuable source of data, as OECD's regional classification is similar to the NUTS regions (TL2 corresponds to the EU's NUTS 2 classification). Therefore, the NUTS 2 level will be the basis for the analysis of growth and competitiveness of Central European regions in the last decade. These regions are listed in the Table 11 of the Appendix.

2.2. Economic performance in regions of Central Europe: indicator of competitiveness

The economic performance of regions can be considered as an indicator of competitiveness. While other measures of competitiveness would include the employment or unemployment rates, labor productivity or overall measures of wellbeing, this paper will follow the approach used in similar studies and focus on trends of GDP per capita as the main indicator of regional competitiveness.

Economic growth in Central Europe has been uneven over the last decade, both at the national and the regional levels. As presented in Figure 2, the GDP per capita of Central European countries (CE-5) has been steadily increasing during the last decade. The only exception is the year 2009, when the global crisis has started to affect the performance of all European economies. The CE-5 economies have on average grown at a faster rate than the EU-27 countries. For example, the GDP per capita[5] in EU-27 countries grew on average 2.3% in the period 2000-2009. At the same time, the growth rates of CE-5 countries were double or triple that amount: from 5.5% in Slovenia to an astonishing 12.2% in the Slovak Republic. Even though the countries have succeeded to reduce the development gap with the rest of the Europe, the GDP per capita of all five countries remains lower than 75% of the European average.

Figure 2: GDP per capita in CE-5 countries (Euro, current market prices), 2000-2009

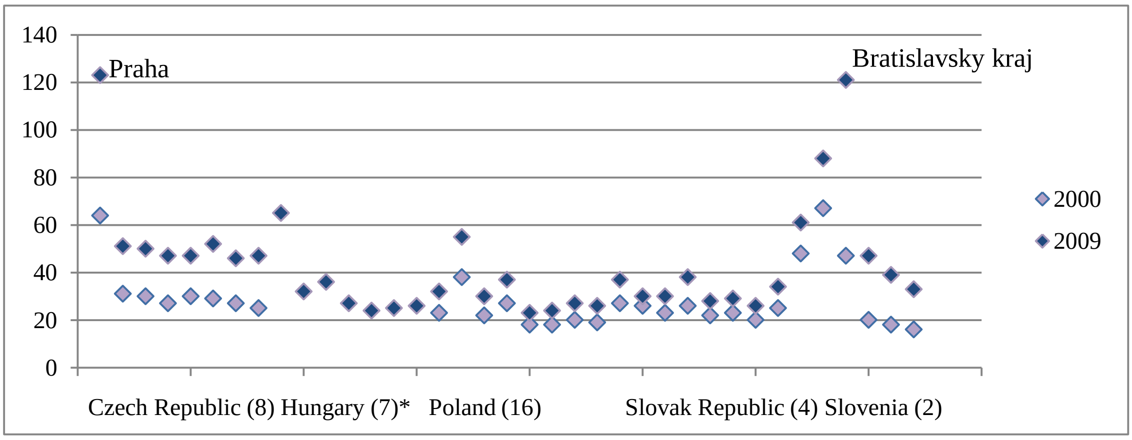


Source: Eurostat.

Further variations can be observed when looking at the CE-5 regional perspective, especially between the capital regions and the rest of the country. The GDP per capita in current market prices of all 37 Central European regions is below the European average in 2009, with the exception of the capital regions of Bratislava and Prague, as presented in Figure 3.

[5] GDP per capita in Euro, current market prices; Eurostat.

Figure 3: Regional GDP per capita in CE-5 countries (% of EU average), 2000 and 2009

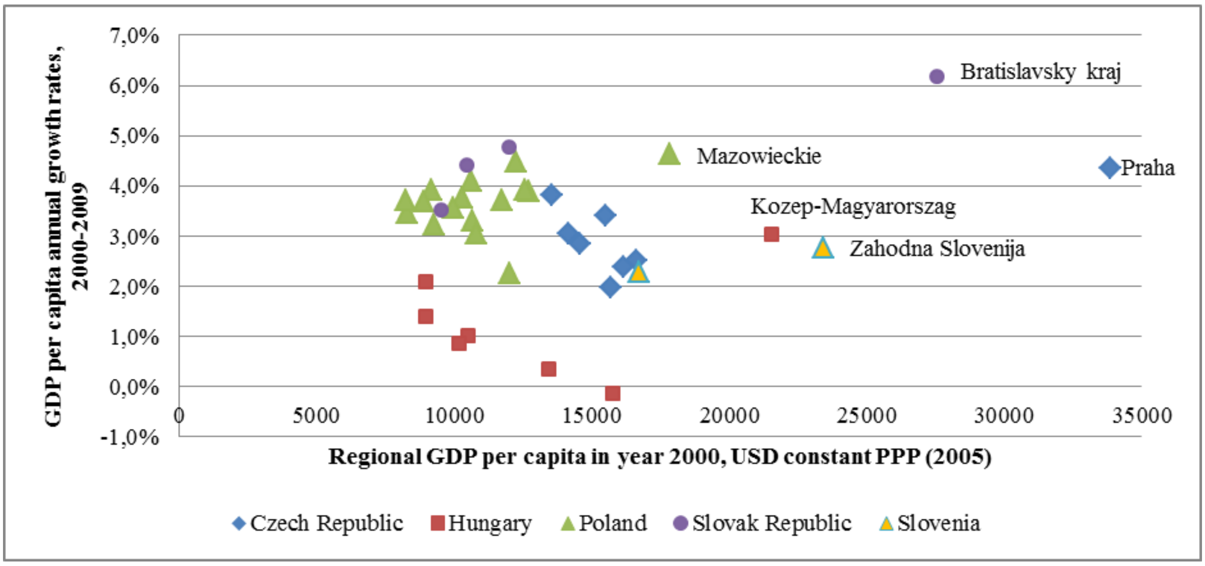


Source: Eurostat. Note: Regional data for Hungary in 2000 not available.

The capital regions in all five countries largely influence the performance of the national economies. For example, in 2009, Hungary's capital region has accounted for 50% of the national GDP. Similar situation is recorded in capital regions of Bratislavsky Kraj (Slovakia) and Praha (Czech Republic), which accounted for more than a quarter of their national GDP in 2009 (28% and 25% respectively). However, while the strong performance of the capital regions is often the key driver of national economic growth, at the same time it creates large inequalities with the other regions.

Figure 4 presents the GDP per capita growth rates of CE-5 regions in the 2000-2009 period, in relation to their initial GDP level in the year 2000. Looking at the within-country comparisons, the chart once again demonstrates that capital city regions were characterized by the highest levels of initial per capita GDP. Furthermore, these regions also account for the highest growth rates within the countries. The region of Bratislava has had the highest growth rate of 6.2%, followed by Polish Mazowieckie and Czech Praha regions with 4.6 and 4.3% respectively. These results suggest the high growth rates of urban centers in the capital regions.

Figure 4: Average GDP per capita growth in CE-5 regions (USD constant PPP), 2000-2009

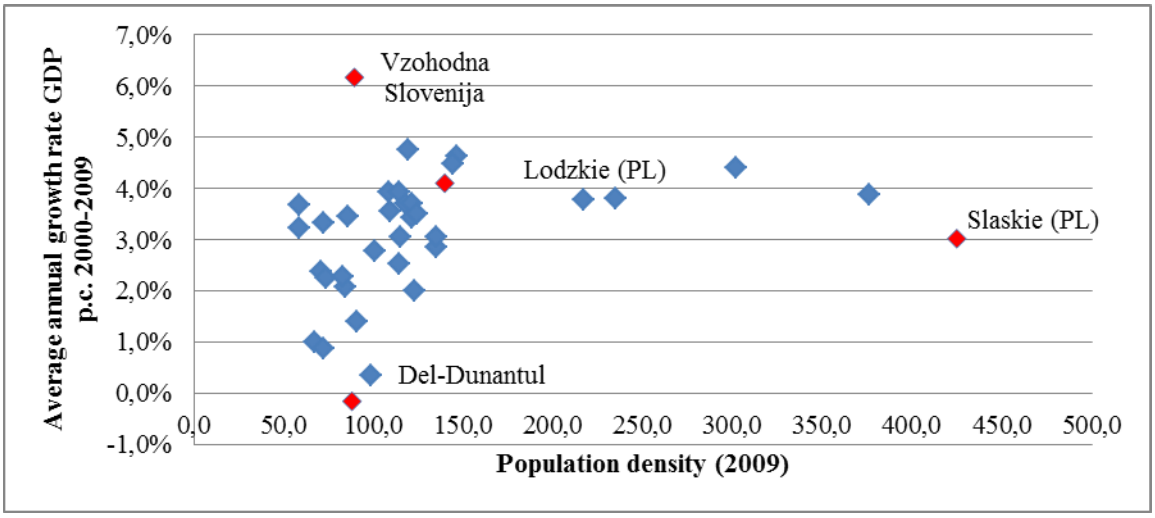


Source: Author's calculations, OECD Regional Database.

However, we can observe large diversity of regional growth outside capital regions as well. The annual growth rates range between -0.2% in Hungarian Nyugat-Dunántúl and 4.8% in the Slovak region Zapadne Slovensko. Furthermore, one can observe that many Slovak, Polish and Czech regions achieved higher growth than, for example, the capital regions of Budapest and Ljubljana. This suggests different growth opportunities among regions, since both more and less urban regions have grown in the past decade. These findings are in line with earlier research (OECD 2011, 37) that growth can be achieved outside large agglomerations as well.

Furthermore, the data show that high population density is not one of the key determinants of the regional GDP growth in Central Europe. Figure 5 below shows the relationship between the population density and the average annual GDP growth rates during the 2000-2009 period. With the exception of the Praha region, with the population density of over 2,500 people per km^2 (excluded from the chart), other CE-5 regions are relatively similar in terms of their population density, and no pattern can be observed with the growth rate. Even looking at the within-country comparisons, we can observe the example of two Polish regions, the less populated Lodzkie has managed to reach higher growth rate than the more densely populated Slaskie region.

Figure 5: Population density and average GDP per capita growth in CE-5 regions



Source: Eurostat.

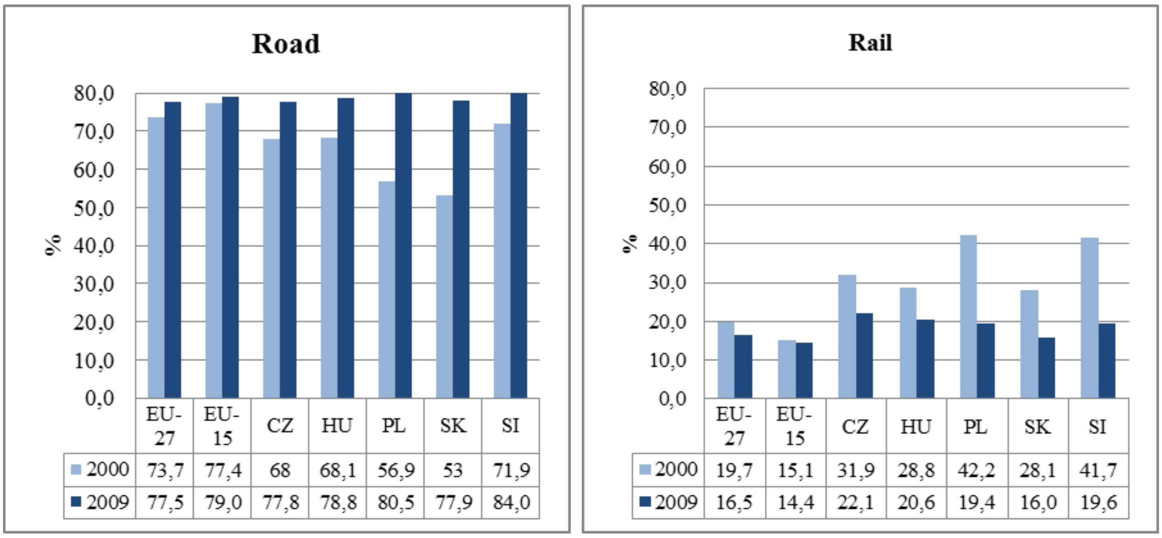
The presented different growth rates between regions considering their initial level of GDP, capital regions or population density show that no simple pattern can be established. These findings then support the standpoint that the notion of a typical, or an average, region has little meaning and therefore is not the optimal solution for designing the regional development policies. Instead, the policies need to be targeted to specific regions, in line with the European place-based development strategies. Even though such policies are in general more difficult to manage (Barca 2009), the overview of only five Central European countries reveals large differences among the regions. Therefore, the policies need to take into account the particular context of the regional area.

In conclusion, this section has illustrated the development gap of CE-5 regions with the European average, but has also demonstrated that some regions have successfully realized their growth potential during the last decade. The data demonstrate that growth potential exists in different regions: within and outside the capital regions, more and less populated, as well as more and less developed ones. Therefore, we can conclude that any region can capture the growth opportunities with the right combination of factors. The remainder of the chapter will describe the regional trends regarding the development of infrastructure, human resources and innovations in CE-5 regions. Their potential relationship with economic growth and competitiveness will be explored in the next chapter.

2.3. Development of transport infrastructure in Central European regions

During the transition period, the transport sector of central European countries has been transformed, as the road sector took over the majority of traffic. The railway lines in general suffered from a large maintenance backlog, and were not able to attract the passenger or freight traffic. As the railways have lost their competitive edge, this transport was taken over by the road sector. However, since the road sectors were not able to accommodate the increased transport, this caused bottlenecks on the available roads, increasing the travel times and overall costs, which has had a negative impact on the competitiveness and the overall quality of life (Steer Davies Gleave 2009). This modal shift continued through 2000s (Figure 6); the modal share of railways has been decreased by over 20% in some countries (such as Poland and Slovenia), in favor of the road sector.

Figure 6: Modal split of freight transport between road and rail (%), 2000 and 2009



Source: Eurostat.

The CE countries have therefore focused on upgrading their transport infrastructure during the last decades. In the 2000-2009 period, over 65 billion Euro was invested into the development of motorway and road networks (International Transport Forum). The figures are largely influenced by Poland, which has invested over 23 billion. Additional 13 billion Euro was invested into development and rehabilitation of rail infrastructure, of which more than half was invested by the Czech Republic.

Even though the investment data is not available on the regional level, it should be noted that a large portion of the infrastructure investments aimed to reduce the gap between the less and the more developed EU regions (European Commission 2010, xviii). While the financial resources are only illustrative of the scale of investments which was undertaken in the last decade, further analysis will focus on the physical indicators, i.e. the length and the density of the road and rail networks. In lack of more detailed data, physical indicators are considered to be an approximation of the accessibility of regions to other markets, even though these measures cannot incorporate the quality of the networks, or interlinkages between different transport modes[6]. Furthermore, while it was seen that the passenger and cargo split in these regions is greatly in favor of road and rail transport, it should be noted that other modes of transport can play a significant role in some regions (e.g. sea transport in Polish regions). However, the analysis of other types of infrastructure investments, such as airport, seaports or inland waterway transport is outside the scope of this paper, due to limited data availability.

2.3.1. Motorway and road network

The physical indicators, such as increased length and density of the motorway network, are illustrative of the network expansion which has taken place over the last decade. All observed

6 The road and rail network accessibility in European regions in 2005 has been analyzed by Ecorys Nederland BV, 2006.

countries have increased their motorway network (Figure 9 in Annex). However, better measure of the availability and concentration of the motorway network is the motorway density, which compares the length of the motorways to the area (Eurostat 2011b). While the motorway densities in CE remain significantly lower than the European average, significant progress has been made (Figure 10 in Annex). The largest relative increase of density was recorded in Hungary, from 5 to 14 km/1000 km^2. While Slovenian density is comparable with the European standards (35 km/1000 km^2), Czech, Slovak and Polish motorway density remains very low (less than 10 km/km^2).

This progress is reflected also on the regional level. On average, the density of the motorways in CE-5 regions has more than doubled in the 2000-2009 period: from 5.2 km/1000 km2 in 2000 to 11 km/1000 km2 (Table 3). Some regions have gained access to motorways for the first time; over 250km of motorways were constructed in Hungarian regions Del-Dunantul and Észak-Alföld, which had no motorways in 2000. In the Czech Republic, over 120 km of new motorways were constructed in three regions which had no motorway network in 2000.

Table 3: Density of the motorway network at regional level in CE-5 countries (km/1000km^2)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mean	4.9	5.1	5.4	5.8	6.6	7.0	7.8	9.4	10.4	10.7
St. Dev.	8.9	8.9	9.5	9.5	10.1	10.5	10.7	12.1	12.8	12.7
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	46.2	46.2	50.2	50.0	50.2	52.1	52.1	53.6	53.6	53.6
N	34	34	34	35	35	35	35	37	37	37

Source: Author's calculation based on Eurostat data.

However, the development of the motorway network was uneven, illustrated by the increasing standard deviation (10.9 in 2000 to 14.4 in 2009). The highest motorway densities are expectedly found in capital centers of Ljubljana, Budapest and Prague. This is comparable with the EU-27 regions in general (Eurostat 2011b), where the largest densities can be found around capital cities. In general, the European capital regions are characterized by dense motorway network, to serve the transport demand of the capital and the wider metropolitan area (Eurostat 2011b, 2). On the other hand, situation is particularly challenging for Polish regions, as six of them still have no motorway connections in 2009.

The development of the road network has received less attention. Even though Table 4 presents the increasing average density of the road network during the 2000s, it should be noted that the data from 2004 onwards are largely influenced by the revised road network figures in Hungary. Even more importantly, since the majority of the investments were captured by the motorways, road networks may be in poor condition, suffering also from a maintenance backlog. However, these considerations are beyond scope of this physical indicator.

Table 4: Density of the road network at the regional level in CE-5 countries (km/1000km2)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mean	886	895	882	875	1232	1241	1249	1285	1288	1294
St. Dev.	427	440	423	434	596	600	608	610	617	624
Minimum	125	125	125	125	125	125	125	125	125	127
Maximum	1998	2040	2022	2018	3253	3229	3247	3204	3256	3295
N	34	34	34	35	35	35	35	37	37	37

Source: Author's calculation based on Eurostat data. Note: Revised data for Hungary 2004-2009.

2.3.2. Railway network

The railway network in the CE-5 countries is characterized by a high density, comparable to the EU average (Figure 11 in Annex). Therefore, unlike the motorway network, it did not require significant investments into the expansion of the network itself. The new investments were mostly targeted to improving the quality of the network, while some railway lines have been closed due to their poor condition. While the Czech total railway network was slightly expanded, Polish network was significantly rationalized. During the 2000-2009 period, over 2000 km of railway lines in Poland were closed, decreasing its total network by 10 percent.

Different approaches can be observed on the regional level as well. For example, in the Czech Republic, while the length of the national railway network has increased by 134 km, the development among regions was uneven. In only two regions, a total of 224 km of railways were closed down, while the capital region was provided by an additional 64 km of railways. The Czech Praha region remains one of the EU-27 regions with the highest railway density (500 km/km2). However, it should be noted that such figure is partly due to the traditionally large motorway network, and partly due to the very small size of the region (Eurostat 2011b, 4). On the other hand, the railway density was decreased in most of the regions of Poland and Czech Republic. These trends are summarized in Table 5. While the average railway density has slightly increased, from 96 to 100 km/km2, the differences among regions have increased, as presented by the standard deviation.

Table 5: Density of the railway network at the regional level in CE-5 countries (km/1000km2), 2000-2009

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mean	96.0	94.3	95.3	86.1	96.6	96.9	96.6	96.4	97.5	100.4
St. Dev.	56.0	57.3	60.4	34.4	74.9	75.8	75.7	75.1	76.0	84.7
Minimum	38.8	39.2	39.2	33.8	33.4	33.8	33.8	34.9	37.6	37.6
Maximum	371.0	375.1	385.1	184.0	483.9	495.9	494.0	489.9	495.9	499.9
N	34	34	34	33	34	35	35	35	35	28

Source: Author's calculations based on Eurostat data.

This section has outlined the trends in development of transport infrastructure in CE-5 countries, focusing on the specifics on the regional level. While this paper primarily aims to analyze the impact of transport infrastructure investments on regional growth and competitiveness, other complementing factors cannot be neglected. The remainder of the chapter therefore describes several key indicators of human resources and innovation activity, to be used in the analysis in the following chapter.

2.4. Review of other regional development policies in Central Europe

2.4.1. Human resources

One of the key measures of human resources in terms of its effect on regional growth is the attainment of tertiary education. In general, the regions with a higher share of tertiary educated have higher levels of productivity (European Commission 2010a, 33). The 2007 analysis of the relationship between regional productivity and regional attainment of tertiary education has concluded that for every percentage point of higher education above the average, the productivity was higher for 780 PPS (European Commission 2010a, 34). Therefore, the analysis concludes that the increase in the share of tertiary educated would ultimately result in higher GDP. Even though these findings need to be interpreted with caution, since other factors should also be taken into consideration, it is still illustrative of the relevance of the tertiary educated population.

However, the countries of Central Europe are generally lagging behind the European average in tertiary education attainment (26% of the EU-27 in 2009, Eurostat). While Slovenia and Poland are approaching this target, Slovak and Czech Republic are at only 16 percent in 2009. The data prior to 2008 are not available, making it not possible to analyze the progress of these countries over the last decade.

On the regional level, however, we can see some high performers exceeding the EU average. In particular, the regions with the highest portion of people with tertiary education are the capital regions of Bratislava (31.9%) and Prague (30.3%). Similar high portions are recorded in the regions around Budapest and Warsaw (29.3%), as well as Ljubljana (28.3%). On the other hand, the Czech region Severozapad has only 8% of population with higher education, followed by Slovak regions of Vychodne and Zapadne Slovensko with only 13%. On average, however, the shares of tertiary education are increasing across regions (Table 6 below).

Table 6: Tertiary education attainment at regional level (in % of 25-64 population), 2008-2009

	2008	2009
Average	17,5	18,7
St.Dev.	5,3	5,4
Minimum	6,8	8,4
Maximum	29,2	31,9
N	37	37

Source: Eurostat.

2.4.2. Innovation

Innovation is the third main category of key factors influencing the regional growth and competitiveness. While the earlier research has demonstrated the benefits of innovation activities on economic growth (OECD 2009a), the regional EU policies have also highlighted its importance including in as one of the cornerstones of Europe 2020 policy. The target for the national and regional economies is investing 3% of GDP in research and development activities by 2020.

The European countries have on average invested around 2% of GDP in 2009. While Czech Republic and Slovenia are just slightly below the European average, Hungary, Poland and Slovakia are significantly lagging behind. Poland and Slovakia invest less than 1% into innovation, Slovakia is also the only country which has even decreased its investments into innovation: from 0.65% of GDP in 2000 to 0.48% in 2009.

However, over the last decade, these countries have increased their investments. The regional level data demonstrate massive growth of expenditures for research and development, from an average 25.8 in 2000 to 102.4 Euro per inhabitant in 2009 (Table 7). The regions with highest R&D expenditures are the capital regions of CE-5 countries (led by Praha with Euro 641), while, on the other hand, the majority of the Polish and Slovak regions are investing less than Euro 50 per inhabitant.

Table 7: R&D expenditures at the regional level (Euro per inhabitant), 2000-2009

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mean	25.8	42.2	46.2	53.8	58.7	70.3	82.3	91.3	104.4	102.4
St. Dev.	26.8	52.3	60.5	73.3	81.6	95.7	114.6	131.4	144.3	133.6
Minimum	4.1	4.1	2.8	2.2	3.1	3.8	4.3	6.8	8.0	6.6
Maximum	105.6	251.5	285.1	320.3	357.8	454.2	572.9	694.6	743.5	641.3
N	27	35	35	37	37	37	37	37	37	37

Source: Eurostat Regional Data.

Another indicator of innovation activities is the number of patent applications. Table 8 below summarizes the regional trends over the 2001-2009 period. On average, the number of patent applications has been increasing until 2007, with a sharp decline until 2009, which could be understood as a consequence of the global economic crisis.

Table 8: Number of patent applications to European Patent Office at the regional level (patents per million inhabitants), 2000-2009

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mean	n.a.	2.9	2.0	7.6	8.6	9.1	10.6	13.0	11.6	4.8
St. Dev.	n.a.	5.5	1.9	11.6	14.9	12.7	12.8	14.5	13.7	4.4
Minimum	n.a.	0.1	0.3	0.1	0.2	0.4	0.5	2.2	0.6	0.1
Maximum	n.a.	27.4	6.9	56.3	62.0	56.2	59.5	69.4	74.6	17.7
N	n.a.	22	14	28	29	37	37	36	37	37

Source: Eurostat Regional Statistics.

It should be noted that the above indicators are only an approximation of the innovation activity on the regional level, since the innovation the innovation activities of the companies may be reported in their headquarters, therefore not capturing the effects of the innovation activities in several regions (European Commission 2010, 49). As announced, the presented data on transport infrastructure, innovation and human resources will serve as an input to the quantitative analysis in the following chapter.

Chapter 3: Empirical analysis of relationship between transport infrastructure and regional competitiveness in Central Europe

In line with the theoretical framework outlined in Chapter 1, this paper aims to explore whether the development of transport infrastructure has had a positive impact on competitiveness in regions of Central Europe (Hypothesis 1). Furthermore, the analysis will also reveal whether the impact of infrastructure investments is reinforced by complementing policies in these regions, such as human resources or innovation activities (Hypothesis 2).

3.1. Description of the empirical model

In order to test the research hypotheses, a linear regression model with panel data has been developed. The panel data consists of 37 NUTS 2 regions of Central Europe (Czech Republic, Hungary, Poland, Slovak Republic and Slovenia), over the 2000-2009 time period. The main source of data is the Eurostat Regional Statistics, complemented with OECD's Regional Database. Since there are missing values for particular time periods or variables at the regional level, the panel is unbalanced. The panel model is specified with the fixed effects, i.e. controls for time, country and region effects with dummy variables.

In the model, the dependent variable (y) is competitiveness, which is being measured by the level of GDP per capita (in USD constant PPP, year 2005). Competitiveness is to be explained by several independent variables$(x_1, x_2, \dots x_k)$: in the first place, the availability of transport infrastructure is considered as the main explanatory variable, but the impact of human resources and productive environment (innovation) is considered as well. The following regional indicators have been chosen as explanatory variables, in line with earlier research which has been done (Cambridge Econometrics and Ecorys 2003):

(i) Measures of transport infrastructure

a. Motorway density

(total motorway kilometers in the region relative to its area, km/1000km^2)

b. Road density

(total road kilometers in the region relative to its area, km/1000km^2)

c. Railway density

(total railway kilometers in the region relative to its area, km/1000km^2)

d. Electrified railway density

(total electrified railway kilometers in the region relative to its area, km/1000km^2)

(ii) Measures of human capital

a. Tertiary education attainment (percent of working age population 25-64 with tertiary education attainment)

(iii) Measures of productive environment

a. Total expenditure on research and development (Euro per inhabitant)

b. Number of patent applications to European Patent Office (patents per million inhabitants).

As the first step of the quantitative analysis, a bivariate correlation analysis has been performed, to identify the strength of the relationship of the above variables with regional competitiveness. Afterwards, the variables have been analyzed by a multivariate linear regression, in order to test the first hypothesis. This linear regression model can be generally explained by the formula:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \epsilon$$

Furthermore, to test the second hypothesis, interaction variables have been added to the model. More specifically, the model examines to what extent the interaction of infrastructure with innovation or human resource variables had an impact on regional competitiveness. Therefore, the extent to which one independent variable can influence the dependent one (y), depends on the other independent variable (x2). The model can be described by the following formula:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_1 x_2 + \epsilon$$

The results of the described quantitative analyses are presented in the next section, to be followed by interpretations and policy recommendations.

3.2. Results of the analyses

3.2.1. Results of the bivariate correlation analysis

As the first step of the analysis, a simple bivariate correlation analysis has been performed. The data show a strong linear relationship between GDP and most of the variables, as measured by the Pearson coefficient of correlation (Table 12 in Annex). A strong positive relationship can be noted between the level of GDP per capita and the density of transport infrastructure in the presented data. The correlation is statistically significant, with a significance level $p < 0.001$. The data therefore indicate that regions with higher GDPs per capita are also characterized by higher density of motorways, railways and electrified railways. Furthermore, the analysis also shows strong correlation with the innovation and education variables.

However, the data also show there is no statistically significant linear relationship between road density and the GDP per capita. Moreover, unsurprisingly, the density of railways is very strongly correlated with the density of electrified railways (coefficient of 0.89), pointing out to the issue of multicollinearity. Since it may influence the strength and the statistical significance of the variables in the regression analysis, the density of electrified railways was excluded from the majority of the regression models. The same applies to road density, due to lack of a significant linear relationship.

3.2.2. Results of the multivariate linear regression models

The results of the multiple regression models are presented in Table 9, showing the relationship of GDP per capita with several combinations of explanatory variables (Models 1-12).

Infrastructure. The data show that there is a large positive association between the transport infrastructure and competitiveness. In contrast to the findings of the previous research, it appears that the development of transport infrastructure in CE regions has been able to increase the regions' competitiveness on its own. Taking into consideration that the observed regions have had poor infrastructure connections, and that the majority of public investments over the last decade were primarily targeting the infrastructure development, these findings are reasonable. The data show that when the motorway density increased for 1 km/km^2, the GDP per capita would also increase in the range between 168 and 200 Euros per capita (Models 6 and 7, $p<0.001$), holding all other variables constant. These findings remain consistent even with addition of human education and innovation variables (Models 7-9), regional dummies (Model 10), as well as additional control variables (Models 11 and 12). The impact of the railway density also has a large statistical significance ($p< 0.01$), but at a much lower scale.

Innovation. Table 9 also shows positive coefficients between innovation in terms of R&D expenditures and regional competitiveness. An increase of R&D expenditures by one Euro per inhabitant is related to the regional GDP per capita increase of 20-25 Euros, holding other variables constant (Models 8 and 9). On the other hand, no statistically significant relationship between the number of patent applications on the competitiveness could be established. While these results may seem surprising, one should refer to the already mentioned possible limitations of the number of patents as the measure of the innovation activity (section 2.4.2.).

Human resources. The data demonstrate strong association of human resources and regional competitiveness. More specifically, the model shows that the increase of tertiary education attainment by 1% is related to an increase of GDP per capita by 441 Euros, holding other variables constant (Model 9). While these findings are striking and highlight the benefits of highly qualified labor force, it should be noted that the regional data on education are available only since 2008. Therefore, the strength of the conclusions is considerably affected by a small number of observations.

To test the robustness of the above findings, two additional control variables and a capital city dummy variable were introduced to the models. In line with the theoretical model outlined in Section 1 (Table 1), the analysis aimed to also include the measures of technological infrastructure and migration trends[7]. Lack of regional data did not make it possible to capture other effects of productive environment, such as institutional capacity or level of internationalization (e.g. international trade or FDI investments). Nonetheless, the relationship of motorway and railway density with GDP per capita remains solid. The same findings remain when using a dummy variable to control the regional effects (Model 10).

For an additional robustness check, an alternative measure of regional competitiveness was used as well; instead of the level of GDP per capita, the model has used the regional employment rate (Model 13). Once again, motorway density and R&D expenditures are shown to have a strong positive association with regional competitiveness in Central Europe

[7] The availability of ICT infrastructure was measured by the number of households with broadband access (%), while the indicator of migrationary flows was migration inflows relative to total population in a region (%), excluding intra-regional migrations. Eurostat data.

(these coefficients are all significant at 99% level)[8]. In summary, it can be concluded that the first hypothesis has been confirmed: the development of transport infrastructure increases the regional competitiveness in Central Europe during the last decade. The most significant infrastructure variable, highly relevant across all analyses, is motorway density.

The regression models also showed a positive and statistically significant relationship between GDP per capita and R&D expenditures, as well as with the education level. The test of combined effects of these variables with the infrastructure development was done in separate models (Models 14-16). The data show that the coefficients of the interaction variables including motorway density are statistically significant and positive, showing that the positive effect of motorway density on GDP per capita is larger in regions with higher R&D expenditure, and higher attainment of tertiary education. It should be noted that the coefficient including R&D investments is relatively small, while the education investments seem to have a large interactive impact. The analysis including variable of railway density is not statistically significant, even though it shows a positive effect. Therefore, in summary, we can conclude that the second hypothesis has been confirmed as well, that the impact of infrastructure investments is larger in regions with higher education attainment or higher innovation activity. However, these findings have been confirmed only for the motorway network.

[8] Model 13 shows a negative relationship between railway density and employment rate. These puzzling findings could be attributed to the restructuring of heavy industries in the CE-5 regions, but answering this question would require a more detailed analysis, which is outside the scope of this paper.

Table 9: Results of the multivariate regression analysis

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Constant	3954.29 (319.39)***	4469.65 (837.92)***	5414.399*** (308.896)	5298.37 (297.2)***	-318.9 (1568)	-876.283 (615.041)	6998.973 (348.010)***	8559.381*** (780.384)	-1102.952 (1320.067)	5198.531*** (1695.590)
Motorway density	193.785 (17.4)***	196.51 (19.63)***	161.904*** (17.355)	125.364 (17.45)***	168.55 (28.9)***	200.333*** (13.152)	182.764*** (16.01)	177.169*** (16.630)	167,458*** (24.794)	169.796** (65.912)
Railway density	27.562 (2.486)***	43.93 (10.40)***	4.596 (3.389)	3.990 (3.08)	-	26.763*** (1.934)	10.207*** (2.696)	-7.867 (9.783)	16.245*** (3.846)	16.890 (15.699)
Road density	-	-0.867 (0.515)	-	-	-	-	-	-0.418 (0.481)	-	-
Electrified railway density	-	-12.877 (14.03)	-	-	-	-	-	-19.470 (13.176)	-	-
R&D expenditures	-	-	26.306*** (2.796)	27.13 (2.4)***	-	-	20.338*** (2.277)	25.333*** (2.584)	4.778 (3.707)	34.165*** (3.216)
Number of patents	-	-	-25.925 (33.557)	-	-	-	-42.343 (31.141)	-41.266 (35.526)	-55.837 (38.334)	-74.554** (23.464)
Tertiary education			-	-	331.8 (83.0)***	-	-	-	440.998*** (71.542)	-
Country dummy	No	No	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No
Year dummy	No	No	No	No	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Region dummy	No	No	No	No	No	No	No	No	No	**Yes**
R2; adjusted R2	0.62; 0.62	0.62; 0.62	0.83; 0.83	0.78; 0.77	0.93; 0.92	0.84; 0.84	0.90; 0.90	0.91; 0.91	0.96; 0.95	0.97;0.96
N	224	161	171	216	62	224	171	147	62	171

Source: Author's calculations based on the Eurostat Regional Statistics. The variable GDP per capita data used from OECD's Regional Database.

Note: *significant at the 95% confidence level. ** significant at 99% confidence level. *** significant at 99.9% confidence level.

Table 10: Results of the multivariate regression analysis including control and interaction variables

	Model 11	Model 12	Model 13
Constant	9728.041* (3851.479)	6195.667*** (323.934)	65.726*** (0.796)
Motorway density	265.701*** (28.556)	146.388*** (12.660)	0.182*** (0.035)
Railway density	26.162** (6.762)	12.931** (2.347)*	-0.025*** (0.006)
R&D expenditures	9.475 (5.688)	19.105*** (2.821)	0.025*** (0.005)
Tertiary education	-	-	-
ICT	-83.282 (94.570)	-	-
Migration	-	-1715.005** (504.201)	-
Country dummy	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes
R2; adjusted R2	0.95; 0.94	0.9; 0.9	0.72; 0.70
N	34	153	203

	Model 14	Model 14	Model 16
Constant	1605.495* (815.066)	1565.831 (1804.232)	187.413 (895.219)
Motorway density	44.895* (19.339)	-34.568 (87.452)	151.622*** (15.508)
Railway density	9.384*** (2.157)	14.803*** (3.831)	11.873** (3.637)
R&D expenditures	1.022 (2.975)	7.464 (3.911)	16.274*** (3.467)
Tertiary education		290.771** (93.927)	
Interaction variable: Motorway density * R&D expenditures	0.926 (.139)***		
Interaction variable: Motorway density & education		290.771** (93.927)	
Interaction variable: Railway density * R&D expenditures			0.003 (0.009)
Country dummy	**Yes**	**Yes**	**Yes**
Year dummy	**Yes**	**Yes**	**Yes**
R2; adjusted R2	0.91; 0.91	0.95; 0.95	0.89; 0.89
N	216	62	216

Source: Author's calculations based on the Eurostat Regional Statistics. The variable GDP per capita data used from OECD's Regional Database.

Note: *significant at the 95% confidence level. ** significant at 99% confidence level. *** significant at 99.9% confidence level.

3.3. Interpretation and recommendations

The models have demonstrated that the availability of transport infrastructure had a strong impact on the regional competitiveness over the last decade in Central Europe. In particular, the development of the motorways has had the largest relevance, which is not surprising considering the deficiencies of the motorway networks in Central Europe compared to the EU-15 countries (elaborated in Chapter 2). Results thus confirm the large relevance of new infrastructure links in these regions which were not well connected with the markets and were constraining to economic development. However, interestingly enough, the data show that infrastructure development was not only the necessary, but also the sufficient ingredient for economic growth (as demonstrated by Models 1, 2 and 7). While it would then seem logical to conclude that further investments would lead to additional increase the regional competitiveness, one should not ignore the potential effects of complementing policies.

The analysis on the interaction of infrastructure with complementing policies shows that the positive effect of transport infrastructure development increases with the increase of R&D expenditure or tertiary education. It should be also noted that the combined impact with R&D investments is quite low, suggesting that regions have not been able yet to realize the potential arising from innovation activities in combination with the transport infrastructure investments.

Considering that both the quantity and the quality of transport links remain below the European average, the development of motorway and railway networks in CE regions will be continued in the following decade as well. Learning from the presented experiences, it can be expected that further transport linkages will open up new market opportunities and further increase the regional competitiveness. However, taking into account the constraints of the current economic crisis, the regions should strive to make the most out of the available public investments. Learning from experiences of other countries (OECD 2009a), economic growth can be further facilitated by a combined approach, making use of the combined effects with the higher education and innovation policies.

Therefore, in summary, two main recommendations arise from the analysis. First of all, CE-5 regions are still not well endowed with infrastructure, which means that further development of transport networks is needed to act as a generator of competitiveness and growth. While the data suggest that these investments were sufficient to generate economic activity, the regions could further benefit from complementing policies in soft infrastructure, especially innovation policies. Therefore, secondly, more attention is needed on design of integrated policies, which will then further increase the regional competitiveness, creating employment and improving their overall economic performance.

3.4. Limitations of the analyses

While the findings of the regression analysis are fairly robust, one should remain aware of the potential limitations. The results of the regression analysis are limited by three main issues: time period, data availability and the general limitations of the regression analysis.

First of all, the time period of the analysis of ten years is most likely not sufficient to capture the potential effects of the transport infrastructure development on regional growth and competitiveness. As earlier research shows (OECD 2009a), the investments into transport infrastructure on average have a time lag of three year before they can influence growth. Therefore, the total impact of the recent investments actually may be underestimated, since it would be even more visible in the future years.

Secondly, the analysis is constrained by the availability of data on the regional level. It can be observed that the number of observations significantly decreases with addition of more variables; for instance, the regional data on the human resources are available only from 2008 onwards. As discussed in the theoretical framework, the regional competitiveness is influenced by a wide variety of factors. The regional statistical data on international trade or investment activities are not available at all, making it unfeasible to control for the effects of EU accession and the benefits of the single market. Therefore, the analysis may be influenced by the omitted variable bias; i.e. inclusion of those variables may alter the final conclusions.

Finally, one can recognize the multicollinearity and endogeneity problems. Considering that the correlation analysis demonstrated the presence of multicollinearity between some variables (Section 3.2.1), it should be noted that the effects of these variables on competitiveness are most likely underestimated. However, on the other hand, the effects of infrastructure investments as individual factors are difficult to be singled out. Furthermore, it should be understood that the assumed relationship between variables may be backward. In this case, for example, one cannot definitely conclude whether the higher density of transport network is the reason of the higher GDP per capita, or whether the wealthier regions, with higher GDP, are able to invest more in the transport infrastructure. While there are techniques for reduction of these potential biases, further analysis is beyond the scope of this paper.

Conclusion

This paper has presented the development of transport infrastructure in regions of Central Europe during the 2000-2009 time period, assessing its relationship with regional competitiveness. The interaction of infrastructure with complementing policies, such as innovation and education, was analyzed as well. The analysis has established a positive relationship of transport infrastructure with competitiveness in CE-5 regions, measured by the level of GDP per capita. The data also suggest that infrastructure development has been able to influence the regional economic performance even without complementing policies. Even though the analysis also shows that positive effect of transport infrastructure increases with the increase of innovation activities or better human resources, this impact is relatively small, highlighting unrealized potential in the observed regions.

Available theoretical and empirical literature, presented in the paper, highlights the potential threats of focusing solely on the development of transport infrastructure. It is understood that for the regions of Central Europe, with inadequate transport links to neighboring markets, further development of transport infrastructure remains a priority. However, those investments, if combined with education and innovation policies, will be able to provide a more sustainable foundation for long-term regional growth and competitiveness. This would assist in further reduction of the development gap of these regions with the European average. The paper has illustrated that growth potential exists in different regions of Central Europe: more or less developed, densely or sparsely populated, as well as outside capital cities. However, in order to realize this potential, policies need to be designed taking into consideration the specific characteristics of the area, in line with the place-based approach to regional development.

While this paper offers a contribution to the design of place-based policies in the area of Central Europe, it should be noted that the analysis is constrained by the current availability of data on the regional level. The EU statistical office has made significant progress over the last years to expand its regional database, but several important indicators are still missing, making it difficult to consider them in policy-related analysis. More specifically, the regional policy-makers would benefit from more extensive data on regional education statistics, as well as external trade and investments. As highlighted throughout this paper, regional competitiveness is a result of a dynamic interaction of multiple factors. In that sense, larger availability of regional data would facilitate more targeted evaluation and planning of regional development policies.

In conclusion, the development of lagging regions remains a challenge for the EU and national policy-makers. The design of place-based policies which will efficiently target the reduction of regional disparities within a specific context, but also make the most of the available public investments, remains the key policy objective for small regions of transition economies.

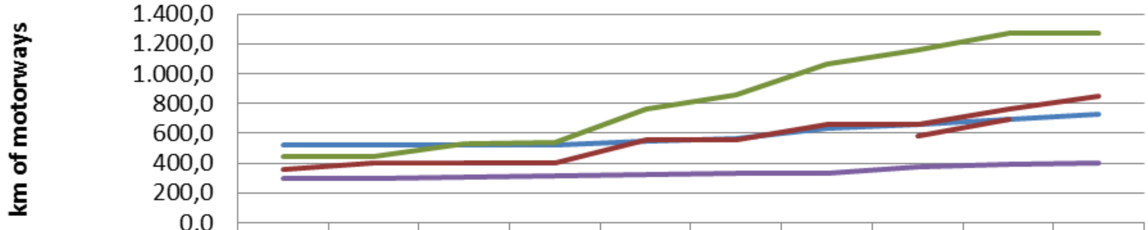
Appendix

Table 11: List of regions in Central Europe (NUTS 2, TL2)

Czech Republic (8)	Hungary (7)	Poland (16)	Slovak Republic (4)	Slovenia (2)
Praha	Közép-Magyarország	Lódzkie	Bratislavský kraj	Vzhodna Slovenija
Strední Cechy	Közép-Dunántúl	Mazowieckie	Západné Slovensko	Zahodna Slovenija
Jihozápad	Nyugat-Dunántúl	Malopolskie	Stredné Slovensko	
Severozápad	Dél-Dunántúl	Slaskie	Východné Slovensko	
Severovýchod	Észak-Magyarország	Lubelskie		
Jihovýchod	Észak-Alföld	Podkarpackie		
Strední Morava	Dél-Alföld	Swietokrzyskie		
Moravskoslezsko		Podlaskie		
		Wielkopolskie		
		Zachodniopomorskie		
		Lubuskie		
		Dolnoslaskie		
		Opolskie		
		Kujawsko-Pomorskie		
		Warminsko-Mazurskie		
		Pomorskie		

Source: Eurostat Regional Yearbook 2011

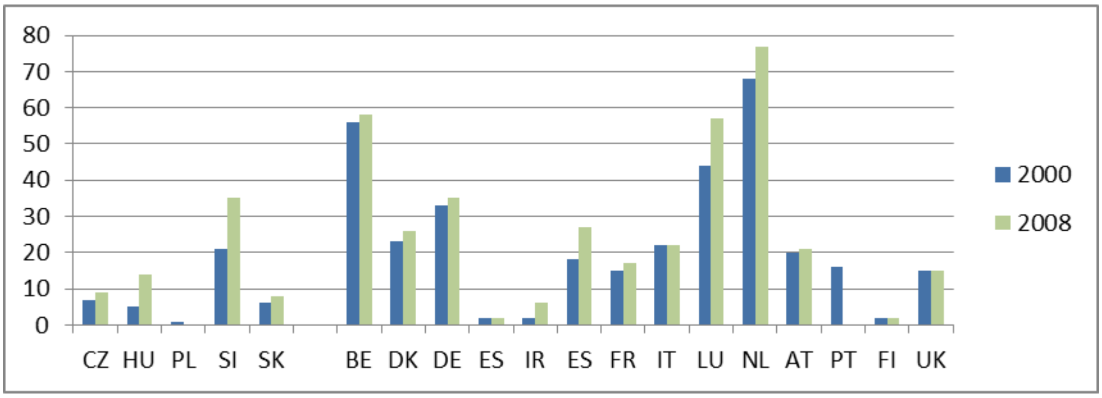
Figure 7: Evolution of the national motorway networks in CE-5 countries (km), 2000-2009



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Czech Republic	517,8	517,7	517,8	517,8	546,3	564,0	633,0	658,0	691	729
Hungary	448,0	448,0	533,0	542,0	761,3	859,3	1.064,9	1.157,4	1.274	1.273
Poland	358,0	398,0	405,0	405,0	552,0	552,0	663,0	663,0	765	849
Slovak Republic	295,7	295,7	306,5	317,7	322,4	333,7	333,7	372,5	392,0	400,0
Slovenia								579	697	

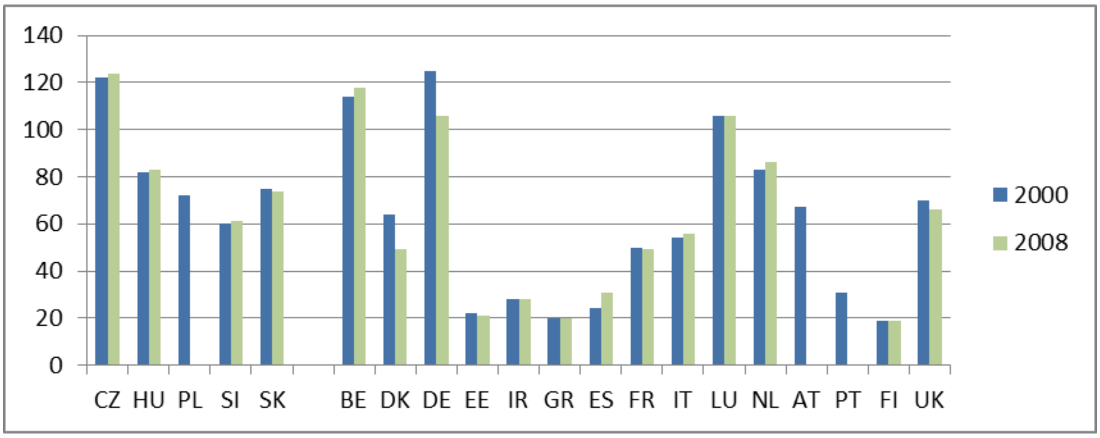
Source: Eurostat

Figure 8: Motorway density (km/1000 km2) in CE-5 and EU-15 countries, 2000 and 2008



Source: Eurostat. Note: Data for Greece not available.

Figure 9: Railway density of CE-5 and EU-15 countries (km/1000km2). 2000 and 2008



Source: Eurostat

Table 12: Results of the bivariate correlation analysis

		GDP per capita	Motorway density (per 1000km2)	Road density (roads per 1000km2)	Railway density (per 1000km2)	Density of electrified railways (per 1000km2)	R&D expenditure (Euro per inhabitant, total)	Patents per million inhabitants	Tertiary education persons 25-64 (%)
GDP per capita	Pearson Correlation	1	,672**	-,116	,658**	,567**	,870**	,651**	,587**
	Sig. (2-tailed)		,000	,055	,000	,000	,000	,000	,000
	N	321	237	273	261	198	307	242	74
Motorway density (per 1000km2)	Pearson Correlation	,672**	1	,198**	,324**	,366**	,554**	,611**	,486**
	Sig. (2-tailed)	,000		,001	,000	,000	,000	,000	,000
	N	237	283	283	269	206	275	217	72
Road density (roads per 1000km2)	Pearson Correlation	-,116	,198**	1	-,276**	,150*	-,100	,152*	,207
	Sig. (2-tailed)	,055	,001		,000	,019	,079	,016	,081
	N	273	283	319	305	242	311	251	72
Railway density (per 1000km2)	Pearson Correlation	,658**	,324**	-,276**	1	,885**	,773**	,511**	,261*
	Sig. (2-tailed)	,000	,000	,000		,000	,000	,000	,039
	N	261	269	305	305	242	297	238	63
Density of electrified railways (per 1000km2)	Pearson Correlation	,567**	,366**	,150*	,885**	1	,659**	,301**	,493**
	Sig. (2-tailed)	,000	,000	,019	,000		,000	,000	,000
	N	198	206	242	242	242	242	214	63
R&D expenditure (Euro per inhabitant, total)	Pearson Correlation	,870**	,554**	-,100	,773**	,659**	1	,666**	,574**
	Sig. (2-tailed)	,000	,000	,079	,000	,000		,000	,000
	N	307	275	311	297	242	356	277	74
Patents per million inhabitants	Pearson Correlation	,651**	,611**	,152*	,511**	,301**	,666**	1	,282*
	Sig. (2-tailed)	,000	,000	,016	,000	,000	,000		,015
	N	242	217	251	238	214	277	277	74

Tertiary education persons 25-64 (%)	Pearson Correlation	,587**	,486**	,207	,261*	,493**	,574**	,282*	1
	Sig. (2-tailed)	,000	,000	,081	,039	,000	,000	,015	
	N	74	72	72	63	63	74	74	74
**. Correlation is significant at the 0.01 level (2-tailed).									
*. Correlation is significant at the 0.05 level (2-tailed).									

Source: Author's calculations based on the Eurostat Regional Statistics. The variable GDP per capita data used from OECD's Regional Database.

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