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What makes regions in Eastern Europe catching up? The role of foreign investment, human resources and geography*

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This paper analyses regional growth in Eastern Europe in the second half of the 1990s, when regional disparities sharply increased. We aim to identify the factors behind growth and investigate in particular the role of (foreign) investment, education and innovation as well as geographical factors in a model of economic growth. The key relationships are estimated with spatial econometric tools on empirical data for the period 1995-2000. We find that foreign direct investment was paramount for growth in that period. EU border regions and capital areas clearly outperformed others. Further, regional growth clusters have appeared. Surprisingly, the high level of secondary education played no role to growth. Higher education, in contrast, was important, also for technology transfer.

JEL classification: R11, P25, C21, F15

Key words: Regional growth, Eastern Europe, foreign direct investment, education, spatial econometrics.

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1. Introduction

This paper wishes to investigate the determinants of regional growth in the Eastern European EU candidate countries. Since their economic prospects are determined by catching-up, growth is a primary issue for these countries.

Since the mid-1990s, we observe a superior growth performance of Eastern European countries vis-à-vis Western Europe, providing evidence that a process of catching-up is underway. However, it shows that there are big internal growth differences within the Eastern European countries. Under this perspective, the question arises why growth rates differ across the regions of these countries. Why do some Eastern regions show a very dynamic growth while others only a weak?

Economic growth theory offers a number of hypotheses with respect to growth determinants, upon which a huge empirical literature emerged in the 1990s. Some investigated growth factors within large, worldwide country sets (e.g. Sachs and Warner 1995, Sala-i-Martin 1997, Gallup et al. 1998), others looked at growth factors within OECD economies (e.g. de la Fuente 1995, Bassanini et al. 2001). A number of studies also investigated growth factors in the EU at the regional level (e.g. Fagerberg and Verspagen 1996; Fagerberg et al. 1997; Vanhoudt et al. 2000; Paci and Pigliaru 2001; Tondl 2001; Badinger and Tondl 2003). In contrast, for Eastern Europe, there are only a few studies at the country level which investigate multiple growth factors (e.g. Campos and Kinoshita 2002) but there are practically no growth factor studies at the regional level.[1]

So far, most country studies on Eastern European growth are interested in exploring the causes of why some countries managed transition and recovery faster than others, and therefore investigated particular factors likely to influence growth in transition. Thus many growth studies focused on the role of institutional reform and market liberalization for growth in Eastern Europe (Hernández-Cáta 1997, Fischer, Sahey and Vegh 1998, Falcetti, Raiser and Sanvey 2002, Havrylyshyn 2000, Fidrmuc 2000) or of economic policies (Barlow and Radulescu 2002). Only a few studies investigate growth

[1] There are, however, some studies which address the issue of regional specialization and employment dynamics in Eastern European countries, e.g. Resmini (2002), Traistaru and Wolff (2002) and Traistaru, Nijkamp and Longhi (2002).

factors which are relevant at the post-transition stage such as investment, FDI and education (Fidrmuc 2000, Campos and Kinoshita 2002).

As transition was completed and regional growth differences in the catching-up process have become manifest in Eastern Europe, however, a general interest arises to know which are the factors behind dynamic growth. In this view, our paper wishes to fill the gap in Eastern European regional growth analysis.

We investigate regional growth in a sample comprising 36 regions from the Czech Republic, Slovakia, Hungary and Poland, and of Slovenia for the period 1995-2000, - a time when those countries had generally started to catch up (WIIW 2002). For that purpose, we created a comprehensive regional databank, EAST RegStat, compiled from national statistical data. Investigating the causes of regional growth in the post transition period we look at a variety of factors which seem to be particularly relevant in Eastern European countries, namely capital accumulation and foreign direct investment (FDI), which reached rather high levels in this period, labour force participation, which decreased due to mounting unemployment, educational attainment of secondary and higher level, where Eastern European countries partly rank fairly high, and innovation. In addition, we investigate the role of geographical factors such as the location in the EU border area or the role of capital areas and spatial dependencies among regions. An important concern of this study is also to investigate factors which may explain technological progress, manifest by a strong increase in productivity in Eastern European regions in this period. Thus we look at the role of innovation activity and technology diffusion in achieving technological progress.

The results indicate that foreign direct investment and location factors are most important for regional growth in Eastern Europe. Border regions, and even more capital areas, often outperform other regions. Moreover, spatial dependencies suggest a tendency of emerging growth clusters in Eastern Europe. With respect to human capital, we find that the high level of secondary education in the population has no significant impact on growth. Higher level education, by contrast, seems to be an important factor for technology diffusion as effected e.g. by FDI.

The rest of the paper is organized as follows: Section 2 reviews the literature and puts forward our hypotheses with respect to growth factors in Eastern European regions. Section 3 sets up the theoretical model to be tested. Section 4 describes our data set EAST RegStat and gives first insights on regional developments from the data. Section 5 explains the estimation procedure and presents the results of the estimations. Section 6 concludes.

2. Likely sources of growth in Eastern European regions in the post-transition period

In principle, growth theory considers two distinct sources of growth. First, growth and hence catching-up is determined by factor accumulation of capital and labour, whereby usually a certain level of human capital is attached to the latter. Second, growth depends on productivity growth which according to the new growth theory can be either generated by own R&D or derive from technology transfer.

The existing empirical growth literature largely concludes that capital accumulation is an important factor for growth, particularly in the early development stages. But also for EU regions, capital accumulation was found to be important for growth (Vanhoudt et al. 2000, Badinger and Tondl 2003). Similarly, the extent of participation of labour in the work process is essential for income growth. For EU regions, this has been shown in several studies (Fagerberg et al. 1997, Carmeci and Mauro 2002, Badinger and Tondl 2003). However, education and technological progress was found to be of much higher importance than factor accumulation in OECD country as well as EU regional studies (e.g. Bassanini and Scarpetta 2002, recently for the OECD; de la Fuente 1996, Fagerberg et al. 1997, Vanhoudt et al. 2000, Lodde 2000, Tondl 2001, Badinger and Tondl 2003, for EU regions).

With respect to Eastern Europe there is still very little empirical evidence on the factors behind dynamic growth. Thus we have no evidence whether the sharp increase of investment, fed also importantly by FDI, has been essential for growth in these economies. We do not know to which extent rising unemployment and falling participation in the work process decelerate income growth. Also with respect to human capital and innovation there is little evidence. There is however a considerable literature that has focused on the role of market liberalization, institutional features

(Hernández-Cáta 1997, Fischer, Sahey and Vegh 1998, Piazolo 1999, Falcetti, Raiser and Sanvey 2002, Havrylyshyn 2000, Fidrmuc 2000) and FDI (Fidrmuc 2000, Campos and Kinoshita 2002) for growth.

Since Eastern European economies are in a very specific situation of economic development, where basically the downsizing of transformation is completed and was replaced by rebuilding and modernization, we may expect that other factors than in the EU economy are important for growth. Furthermore, the determinants of growth may well differ from those in the less developed EU regions since their historical economic trajectories cannot be compared. Catching-up in income after socialism is likely to be very different from the situation of catching-up from a backward economy.

There are a number of factors which we consider potentially important for regional growth in Eastern Europe and which are open for investigation as data is now available. Those are investment, the participation rate, educational attainment, innovation activity, the stock of FDI as well as spatial dependencies and location factors. Our arguments behind these likely growth factors and the existing findings in the growth literature of Eastern Europe will be discussed in the following.

First, with respect to investment, we have to note that domestic saving and capital accumulation have been higher in Eastern Europe than in the EU since the mid 1990s (25 per cent versus 19 per cent on average in 1994-97; Dobrinsky 2001, Campos and Coricelli 2002), whereby foreign direct investment played an important role (13 per cent of investment in 1997/99; Campos and Coricelli 2002). This increase in capital accumulation should have had an important impact on regional growth. There is already some evidence for this argument in the scarce empirical growth literature on Eastern Europe. Campos and Kinoshita (2002) found that capital formation showed a significantly positive effect on growth in Central and Eastern European countries.

Further, there is reason to assume that growth of regional per capita incomes in Eastern Europe in the 1990s has been related to labour market developments. In the first 5 years of transformation, participation rates had in general significantly declined (Boeri 2000) but stabilized in the second half of the 1990s, with the exception of many Czech and Slovak regions. The reasons for a decline in participation rates can be either demographic or related to the labour market. In the first case, emigration and the resulting population aging may have reduced labour participation in Eastern Europe. In the second case, the mismatch of skills and labour saving efficiency gains will have lead to increased unemployment and thus to lower participation. Indeed, unemployment rates had steadily increased in Eastern Europe until 1994, then showed a tendency to decline until 1998 (Burda 1998), but increased again thereafter (Eurostat). Also did employment after a short expansion after 1994 drop again in the Czech Republic, Slovakia and Poland (WIIW 2002). Emigration of active population, either abroad or to other regions in the country, was important and may have contributed to a decline of participation rates as it resulted in population ageing.

The fall in participation rates will lead to reduced growth prospects of a region as produced output has to be shared with a larger inactive population share. Therefore, high unemployment and emigration will reduce the growth potential of a region. Thus the question arises to which extent labour participation rates have been important for regional growth in the post-1995 period.

Next, we may assume that educational attainment, which is given a primary role in endogenous growth models, has played an important role for regional growth in Eastern Europe because of the relatively high education level, - at least of secondary school attainment. 45-55 per cent of the population have finished secondary school. In the richer regions of the EU this rate stands at 41 per cent and in the less developed regions of the EU cohesion countries the rate is only 25 per cent. Higher level education attainment rates are less striking. 5 to 6 per cent of the population have finished higher education, whereas the rate is 10 per cent in the cohesion countries and 16 per cent in the richer EU regions.

As raised above, economic growth theory has strongly argued that education should be considered as an important factor for growth since it provides knowledge and skills that enter into the production process and determine its efficiency (Lucas 1988; Mankiw, Romer and Weil 1992). In addition, higher level education is considered to have a direct impact on the research capacity (Romer 1990). Empirical studies for EU regions have found that educational attainment played a major role for regional growth (Vanhoudt et al. 2000; Tondl 2001, Badinger and Tondl 2003).

Therefore, we may guess that the exceptionally high level of secondary schooling should trigger fast growth in the Eastern European countries. However, this relationship may be less clear for a number of reasons. First, we should know that the high rate of secondary school attainment reflects the fact that vocational schools, - as opposed to general education -, have a much more important role in the accession countries than in the EU. Vocational schools account for 80 per cent of upper secondary education in the East. In the EU, only in Germany and Austria the share of vocational schools is almost equally high with 70 per cent. In contrast, vocational schools account only for 20-40 per cent in the Southern EU countries (Eurostat 2000). This explains the different size of secondary school rates across Europe. Then, as Boeri (2000) points out, qualifications in the East tend to be very narrowly specified and are often not transferable to new jobs. Therefore, high school attainment rates would not reflect the actual level of qualification. So far, growth regressions for Eastern European countries provide mixed evidence. Fidrmuc (2000) found that secondary education has a positive impact on growth, whereas Campos (2002) found a negative impact

Recent growth literature stresses that productivity growth has become the most important source of growth in advanced economies (Easterly and Levine 2001). Given the large productivity gap of Eastern countries, productivity growth should be also highly important in Eastern European regions and should play a central role to maintain the catching-up process. As shown by Dobrinsky (2001) in a growth accounting exercise, total factor productivity growth started to become a driving force for growth in these countries since the mid-1990s.

In principle, productivity growth can be generated either by improving knowledge and skills through education (see above), or by technological progress that either stems from own R&D or is the result of technology transfer.

The common source of technological progress in advanced countries, namely own innovations, may not be that important for growth in Eastern European countries since R&D expenditures are generally not very high, with some exception for the capital regions. In contrast, the second source of technological progress, technology transfer may play an important role for Eastern European regions.

A primary source for technology transfer may be FDI, which has reached a substantial level in the Eastern European countries, not least because lower wage costs, generous tax concessions of the recipient countries to foreign investors, and the prospect of EU integration (Sedmihradsky and Klazar 2002, Altomonte and Resmini 2001). FDI may be a most effective way of technology transfer since not only technology incorporated in capital goods is transferred but also process knowledge and managerial skills. A number of studies appeared recently which attempted to test for technology spillovers through FDI, either on the microeconomic or on the macroeconomic level. The argument is that there is a direct effect of productivity increase in the plant where FDI was received and an indirect effect on productivity of other firms in the same location or same sector (Baldwin et al. 1999). Indirect productivity spillovers may take place through labour force that gets trained and switches to other firms in the area (Fosfuri et al. 2001) or through upstream and downstream interfirm relationships (Blomström and Kokko 1998, Markusen and Venables 1999). Microeconomic studies rest on firm level panel data and explicitly model the transmission mechanisms for technology spillovers, e.g. by starting from the home R&D activity of the investing firm (Lichtenberg and van Pottelsberghe de la Potterie 2001). Technology spillovers will then also be conditioned on the social capability of local firms (Abramowitz 1986) in particular the education level of the local workforce (Borensztein, De Gregorio, and Lee 1998) or own engagement in R&D (Kinoshita 2000). The results of studies using firm level data are mixed. For example, Aitken and Harrison (1999) and others that look at FDI in developing countries find a negative effect on local firms productivity growth, which may be due to a competition effect to local firms. Foreign investment may drive domestic firms operating in the same activity out of the market, leaving small scale, traditional branches to domestic owners and thus resulting into a dual industry structure. Braconier, Ekholm and Knarvik (2001) also find no proof for technology spillover effects of multinational investment in Sweden. Barrios and Strobl (2002) investigate spillovers of FDI on domestic firms in Spain and find that these only occur if local firms are highly export-oriented and thus paying attention to competitiveness. Kinoshita (2000) tests for technology spillovers of FDI on local firms in the Czech Republic and finds that these depend on the extent of own R&D activity of local firms. In contrast, Djankov and Hoekman (1998), which do not account for the absorption capacity of local firms, find no clear evidence for spillovers from FDI in the

Czech Republic. Opposite to microlevel strudies on FDI, there are macroeconomic and sectoral studies which directly assess the growth impact of FDI on the economy or sector. Those come to a positive assessment of its growth effects. Thus, Altomonte and Resmini (2001) could verify a positive growth impact of foreign owned firms on downstream and upstream firms in Poland. Before, De Gregorio (1992) proved the positive growth impact of FDI with a broad sample of countries. Carkovic and Levine (2002), trying to overcome econometric problems of previous studies, also look at a large set of countries and find that FDI only exerts a positive impact on growth in interaction with other variables. For Eastern European countries, Hunya (2002) and Campos and Kinoshita (2002) similarly find that FDI has a positive growth impact, whereby the latter show that it depends on the level of human capital.

Initially, FDI was fairly concentrated on certain regions in Eastern Europe but has recently become more spread (Altomonte and Resmini 2001). Thus the question arises to which extent FDI has been important for growth in Eastern European regions. As described by Resmini (2000), FDI is not targeted at labour intensive sectors in the considered countries, but rather on capital intensive and even science based sectors. Therefore, there should be ample possibility of technology transfer through FDI in the regions regarded in this study. Furthermore, since the educational level and technological ability is relatively high and rather homogenous across regions, such technology transfer through FDI should be facilitated in Eastern European regions.

Given our focus on regional economies, it is straightforward that we also check growth differences under the view of economic geography aspects and spatial effects. First, we shall check for spatial dependencies among regions in Eastern Europe. An obvious way to check for general spatial dependencies is to look at growth spillovers between regions. Such spillovers of growth may be the outcome of a variety of interactions between regions, such as interregional trade flows, labour market interactions, productivity spillovers, etc. A number of regional growth analyses detected such growth spillovers, for example Rey and Montouri (1999), Fingleton (2001), Niebuhr (2001), and Kosfeld et al. (2002). There are also studies in the literature which explicitly analyse the interactions underlying such growth spillovers. For example, Cheshire and Magrini (2000) analyse interregional migration flows, Paci and Pigliaru (2001) analyse productivity spillovers across EU regions, and Paci and Usai

(2001) and Funke and Niebuhr (2001) analyse regional R&D spillovers. Nevertheless, since we wish to account for the total spillover effects between regions rather than single effects, for which data is not always available, we shall focus on growth spillovers. This effect will be analysed by using a spatial econometric model as suggested in the spatial econometric literature (Anselin 1988, Anselin and Florax 1995, Kelejian and Prucha 1998).

Second, we shall test for the relevance of peripherality (agglomeration) effects for Eastern European regions. More precisely, we shall look at access to market demand in Eastern European and EU markets, whereby that access is a function of distance and quality of transport. Thus we shall test the argument that regions which are more closely located to centres in the EU and national centres with high demand and that have a better transportation link to these centres enjoy superior growth.

Third, and alternatively to the second proposition, we shall directly test the question to which extent regions located along the EU border and capital regions register higher growth.

Of course, there are a number of other factors which may have an important influence on growth. First, as we know from country level statistics, foreign trade, above all with the EU, has become very important in the East. However, we can suppose that regions trade to a different extent. Thus it would be interesting to find out whether differences in trade intensity have led to growth differences. Intensive trade usually leads to higher growth since it unleashes pro-competitive effects and facilitates technology transfer. Furthermore, as country level studies have shown, differences in socio-political and institutional factors were responsible for growth differences in Eastern Europe. These factors can be expected to vary even more across regions and thus could be important in explaining growth differences. Unfortunately, for both factors, there are no statistics on the regional level and therefore we cannot test for their effect.

In summary, we shall test the following hypotheses in this paper:

(i) Improved investment was important for regional growth in the post transition period.

(ii) Decreasing participation rates negatively affected regional growth.

(iii) The high educational level promoted regional growth in Eastern Europe

(iv) Innovating regions experienced higher growth rates.

(v) Technology transfer was a major source of regional growth.

(vi) Foreign direct investment was important for regional growth after transition.

(vii) Spatial dependencies and location matters for regional growth in Eastern Europe.

3. The theoretical model

We start from the augmented Solow model as specified by Mankiw, D. Romer and Weil (1992)

$$Y = AK^{a} H^{b} L^{g} \tag{1}$$

where *Y* is income, *K* is physical capital, *H* human capital, *L* labour and *A* total factor productivity. a , b and g are elasticities of output with respect to physical capital, human capital and labour. We assume constant returns to scale so that $a + b + g = 1$

Equation (1) becomes

$$Y = AK^{a} H^{b} (POP \cdot PART)^{g} \tag{2}$$

if population *POP* is different from labour force *L*, and *PART* is the participation rate *POP/L*.

In intensive form equation (2) becomes

$$y = Ak^{a} h^{b} PART^{g} \tag{3}$$

where per capita income $y = Y / POP$, per capita capital $k = K / POP$, and the stock of human capital per person $h = H / POP$.

Since we are interested in the causes of changes in per capita income we write the model in log differences

$$\Delta \ln y = \Delta \ln A + a \Delta \ln k + b \Delta \ln h + g \Delta \ln PART \tag{4}$$

We proxy capital accumulation $\Delta \ln k$ by the investment rate *INV*, $\Delta \ln h$ is the change in educational attainment rates in the population, $\Delta \ln PART$ is the change in the participation rate and $\Delta \ln A$ is technological progress.

At first, education is considered as a factor of production. It represents knowledge that determines efficiency of production. Changes in educational attainment should therefore lead to higher growth. In another sense, however, the level of education determines also the capacity to generate technological progress, i.e. productivity growth (Benhabib and Spiegel 1994; 2003; Temple 1999). Finally, education can also be a conditioning factor for technology diffusion (see below).

In the empirical growth literature a controversy emerged whether indeed changes in education would yield any growth effect. First, Benhabib and Spiegel (1994) and Pritchett (1996), looking at a large set of countries, failed to find a significant relationship between changes in education and growth. In contrast, they detected a positive relationship between the level of education and growth and considered this as evidence that education is primarily a factor which determines technological advance. In the following, de la Fuente and Domenech (2000) and Bassanini and Scarpetta (2001) could demonstrate that the failure to verify positive effects of educational changes was indeed a problem of data accuracy. We shall consider two types of education in this study. First, we look at secondary educational attainment, in which respect Eastern European countries rank fairly high in country comparisons. Second, we look at higher educational attainment which is average in these countries. Considering the possible interpretations of human capital raised in the literature, both the level effect as well as the effect of changes will be examined.

We consider several possibilities how technological progress $\Delta \ln A$ is generated. In line with endogenous growth theory, innovation activity should be the primary source of technological progress. Further, technological progress can happen by technological diffusion which clearly is more important in developing and transition economies that do not yet possess a large R&D sector. FDI may be a particularly important channel for technology diffusion.

As to the first source of technological progress, innovation, we measure R&D activity in the tradition of Romer (1990) and Aghion and Howitt (1992) by the resources devoted to R&D, R&D expenditures

$R\&D_{exp}$ and R&D personnel $R\&D_{pers}$. In line with the critique of Jones (1995), that the absolute scale of R&D resources shows little correlation with technological advance, and recent suggestions of R&D activity indicators used in empirical research (Bassanini et al. 2001, Fagerberg et al. 1997) we use relative indicators. Thus $R\&D_{exp} / Y$ are expenditures in per cent of GVA and in addition to R&D personnel we use the share of R&D personnel in the labour force $R\&D_{pers} / L$ as innovation indicator. Thus we can write:

$$\Delta \ln A = \quad d_{11}(R\&D_{\exp} / Y) \tag{5.1}$$

$$d_{12} R\&D_{pers} \tag{5.2}$$

$$d_{13}(R\&D_{pers} / L) \tag{5.3}$$

Note that according to the above arguments on education, particularly higher level education should also be a direct variable for innovation capacity.

As to the second source of technological progress, technology diffusion, we start from Nelson and Phelps (1966) and Benhabib and Spiegel (2003) and consider the potential of technology diffusion to be a positive function of the technology gap of a region. The technology gap *GAP* is proxied by the productivity gap of Region *i* with respect to the EU average:

$$GAP_i = \left[(Y/L)_{EU} - (Y/L)_i\right]/(Y/L)_i \tag{6.1}$$

so that

$$\Delta \ln A = d_{21} GAP \text{ and} \tag{6.2}$$

$$\Delta \ln A = d_{22} GAP * h \tag{6.3}$$

if we consider that the availability of human capital in the region is a precondition for technology diffusion, as suggested by Nelson and Phelps (1966) and specified by Benhabib and Spiegel (1994; 2003).

Finally, we consider that the presence of foreign direct investment enables technology transfer so that

$$\Delta \ln A = f_1 FDI \quad (7.1)$$

$$\Delta \ln A = f_2 FDI * h \quad (7.2)$$

$$\Delta \ln A = f_3 FDI * (R \,\&\, D_{\exp} / Y) \quad (7.3)$$

where FDI is the stock of foreign direct investment as a share of regional GVA. Alternatively, technology transfer through FDI may be subject to the absorption capacity of the region which may either be determined by its human capital as argued by Borenzstein, De Gregorio and Lee (1998) in the tradition of Nelson and Phelps (1966), or own innovation in the sense of Griffith, Redding and Van Reenen (2000), who argue that own R&D increases the propensity that a region can absorb foreign technology.

Last, we wish to include spatial aspects and new economic geography aspects in our model.

We assume that there are regional growth spillovers so that a region´s growth is determined by the growth of its surrounding regions.

$$\Delta \ln y_t = \mathbf{W} \Delta \ln y_t \quad (8)$$

where $\mathbf{W}$ is the N x N spatial weights matrix of the dimension equivalent to the number of regions N with elements w_{ij} which describes the interaction between region *i* and region *j*. We choose a contiguity spatial weights matrix where $w_{ij} = 1$ if region *i* and *j* have a common border and $w_{ij} = 0$ otherwise.[2]

In addition to growth spillovers, the effect of access to market demand was tested. Hereby we start from the peripherality indicator given as

[2] Alternatively to the contiguity matrix we used two weights matrix specifications where the influence of other regions´ growth declined with increasing distance. One of the form $w_{ij} = d_{ij}^{-d}$ where d_{ij} denotes the distance between the centres of two regions and d
Fingleton 2001; Badinger and Tondl 2003). Another took the form $w = \exp(-d \cdot \quad)$
d various values were tried. In both cases, a high value had to be taken for d in order to get a correctly specified spatial econometric model. This indicates that spatial dependencies diminish very fast between Eastern European regions. Therefore we selected a contiguity matrix as a spatial weights matrix.

$$Peripherality_i = \sum_{j=1}^{N} Y_j \cdot t_{ij} \quad (9.1)$$

$$ACCESS = -(Peripherality) \qquad 0 < ACCESS < 100 \quad (9.2)$$

Peripherality of region *i* is determined by the market size of all regions j located either in Eastern Europe or in the EU, Y_j , and weighted by transport time t_{ij} from region i to region j by lorry (Schürmann and Talaat 2002). This means that a region is the more peripheral the longer it takes to reach large markets. The inverse of the peripherality indicator is the market access indicator *ACCESS*. Regions have the higher market access the closer they are to market demand. The market access indicator ranges between 0 and 100, 100 indicating the highest access. If market access is important for growth, this means that there are tendencies of agglomeration in the sense of the New Economic Geography models (Krugman 1991). Those Eastern regions with high market access to the EU are then potential parts of the European core.

Here the question arises whether the spatial lag model with spatial lags of regional growth conflicts with the access variable. In principle, the market access indicator covers access to market demand of all regions (EU and East), whereby distant ones enter less because of increasing transport time. Since growth spillovers in the spatial lag model cover also demand linkages, market access would have to be considered as an alternative to the spatial lag model if that model is specified with a weights matrix with a distance decay function. Since we use a spatial lag model with a contiguity matrix, which covers only growth spillovers from neighbouring regions, we may include the access variable since it covers also more distant demand effects. If rich EU regions are reachable in a reasonable time, they will have a higher weight in the level of the access variable.

In summary, we can specify the following variants of the model which will be estimated:

$$\Delta \ln y = a + \Delta \ln A \quad + \quad a\Delta \ln k + b\Delta \ln h + g\Delta \ln PART + W\Delta \ln y + u_{it}$$

$$= a + d_{11}(R\&D_{exp}/Y) \quad + \quad ....$$

$$= a + d_{12}\, R\&D_{pers} \quad + \quad ....$$

$$= a + d_{13}(R\&D_{pers}/L) \quad + \quad ....$$

$$
\begin{aligned}
&= \quad .... \quad + d_{21} GAP \quad + \quad .... \\
&= \quad .... \quad + d_{22} GAP * h \quad + \quad .... \\
&= \quad .... \quad + f_1 FDI \quad + \quad .... \\
&= \quad .... \quad + f_2 FDI * h \quad + \quad .... \\
&= \quad .... \quad + f_3 FDI * (R\&D_{exp}/Y) + \quad .... \\
&= \quad .... \quad + \quad ... \quad + \quad .... \quad + EU\ border \quad + u_{it} \\
&= \quad .... \quad + \quad ... \quad + \quad .... \quad + capital \quad + u_{it} \\
&= \quad .... \quad + \quad ... \quad + \quad .... \quad + ACCESS \quad + u_{it}
\end{aligned}
\tag{10}
$$

4. Data issues and a first view on empirical developments in the regions

For this study a unique dataset, EAST RegStat, was created for which a substantial amount of data from national statistical offices was compiled and used along with data from Eurostat. The dataset covers 36 NUTS II level regions from Central and Eastern Europe, i.e. regions from the Czech Republic, Slovakia, Hungary, Poland, and Slovenia, which in the Eurostat regional system is not divided into NUTS II regions. In general, the collected data covers the period 1995-2000. For most indicators, Eurostat data was taken as the principal data source. Missing values were taken from national statistics, if available, checking for trend consistency of time series. For several indicators, however, national statistics were the main data source. In a number of cases data for missing values had to be filled by the means of extrapolation, whereby consistency was checked in various ways, e.g. by allocation of country level data to regions.

The following indicators are used for our analysis:

(i) average annual real growth of GVA per capita 1995-2000

(ii) average gross fixed capital formation (all sectors) 1996-2000

(iii) average annual change in the labour participation rate 1995-2000

(iv) average secondary level and higher level educational attainment in 1996-2000 (per cent of the population with secondary/higher level education)

(v) average annual change of educational attainment rates 1995-2000

(vi) average stock of FDI in per cent of GVA, 1996-2000

(vii) market access indicator 1997[3]

Exact data definitions and sources are given in the appendix.

Note that we calculated the average growth rate by regressing annual logs of GVA on a constant and time trend, rather than computing growth from GVA from the beginning and the end of the period. This should yield growth rates which are less influenced by short term instability, as explained in Temple (1999). Growth rates of other indicators are calculated in the same fashion.

Before presenting the results of our estimation, we would like to briefly describe the main empirical facts on regional development given by our data (see tables 1- 4).

insert tables 1 – 4 about here

Table 1 shows that average regional per capita income growth in the period 1995-2000 in the accession countries was about 4 per cent, except for the Czech Republic where it was little above 0 per cent. However, growth rates varied significantly across regions (see figure 1). In all countries, capital areas showed higher growth than the average growth in the country. In the Czech Republic and in Poland capital area growth was even twice the average. Furthermore we see that the EU border region in Hungary showed a much higher growth than the rest of the country.

insert figure 1 about here

According to table 2, regional investment rates in 1996-2000 ranged from an average of 20 per cent in Poland to almost 40 per cent in Slovakia. Again we find that investment is significantly, namely two thirds higher in capital areas. In Bratislava investment even reached more than 70 per cent of GVA.

[3] We thank Carsten Schürmann, Ahmed Talaat and Michael Wegener for kind permission to use their access indicator statistics.

EU border regions only show slightly superior investment than the average region in the country, except for Bratislava which is both capital and border region.

Table 3 shows that FDI stocks in the Eastern European regions have reached a very high level of 32 per cent of GVA in Hungary and 26 per cent in the Czech Republic, but still much less in the other countries, where the FDI stock accounted for 10-15 per cent of GVA. Also in this context, capital regions have accumulated a higher share than other regions, reaching stocks twice as high as on average. Border regions only have accumulated a higher than average FDI share in Hungary and Slovakia.

The situation with respect to education is shown in table 4. We see that secondary level educational attainment rates are fairly steady across regions within a country. However, there are country differences. In the Czech Republic average regional secondary level attainment accounts for 55 per cent and in the Slovak Republic for 48 per cent, while it is 43 per cent in Poland and Slovenia and 37 per cent in Hungary. Secondary level educational attainment has on average slightly increased in the accession countries regions. By contrast, higher level educational attainment rates are fairly steady across countries ranging between 6-7 per cent. Only Slovenia has a higher tertiary educational attainment rate with 9 per cent. Clearly, higher level educational attainment rates are significantly higher in capital areas, reaching 12-15 per cent in Budapest, Prague and Bratislava. In all countries except for Poland, higher level education has increased in the period under concern.

As higher level education, R&D activity is concentrated in capital areas, where it accounts for 1.5 – 2.4 per cent of GVA. On average, regional R&D rates are fairly modest in the accession countries. Only in Slovenia and the Czech Republic they reach a higher value with 1.6 respectively 1.3 per cent.

5. Results of the estimation

In the following we estimated a spatial lag model assuming a contiguity matrix to model spatial dependencies.

From an econometric point of view the model can be expressed as

$$y = r_1\mathbf{W}y + \mathbf{X}b + u_{it} \tag{11}$$

$$u_{it} = r_2\mathbf{W}u + e_{it}$$

with $|r_1| < 1$, $|r_2| < 1$

where y (N×1) is the dependent, endogenous variable and **X** (N×K) is the vector of K explanatory variables, **W** is the contiguity spatial weights matrix. r_1 and r_2 are (scalar) spatial correlation parameters, and the vector b (Kx1) contains the parameters of the explanatory variables. u_{it} is a non-spherical disturbance term, while e_{it} is assumed to be distributed NID (0, s^2).

For estimation we employ the feasible generalised spatial two stages least squares estimator (FGS2SLS) developed by Kelejian and Prucha (1998) which is considered as an unbiased estimator for spatial econometric models with known asymptotic properties (Debabrata et al. 2003). Estimation is effected with an Eviews programme developed in Badinger and Tondl (2003). As a test for spatial dependence, the standardized Moran´s I statistic is use. We test for the form of spatial dependence (spatial error versus spatial lag model) with the LM_{ERR} and LM_{LAG} test statistics (see Anselin and Rey 1991, Anselin and Bera 1998, Anselin and Florax 1995).

We start to estimate a core model (table 5, model (1)) which includes as explanatory variables regional investment, changes in the participation rate and a spatial lag of growth, measuring growth spillovers from neighbouring regions. All coefficients are significant and have the expected sign. The LM_{LAG} statistic suggests that the spatial lag model is the correct form to model spatial dependencies. The estimates suggest that changes in the participation rate and growth of neighbouring regions are highly important for a region´s growth. In contrast, investment has a positive but fairly modest impact on growth.

insert table 5 about here

We know that participation rates slightly continued to fall with our regions after 1995. Remember that changes in the participation rate partly reflect demographic changes, partly changes in unemployment. Population aging and emigration reduced the participation rate in a part of regions. In addition, unemployment continued to rise, even after transformation was completed. As described by Keune

(2000), the initiated growth process was not accompanied by a similar degree of employment creation. Growth was labour saving. Our results indicate that lower participation rates have been problematic under the perspective to increase welfare in terms of per capita incomes. Low participation limits income growth.

Next, we estimate the augmented Solow model including human capital. First we add the level of educational attainment as advocated by Benhabib and Spiegel (1994), both of secondary as well as of higher level education (table 5, model (2)). Here, only the level of higher education has a positive and statistically significant impact, along with the spatial lag of growth. The other variables become insignificant in this specification. (More precisely, this change of coefficients only happens with the level of higher educational attainment, not with secondary level.) Since higher level education is highly concentrated in capital regions (correlation coefficient 0.76), this specification is likely to capture the capital effect, which is a general growth factor as we shall see below. The coefficient of the level of secondary educational attainment is negative, although not significant. Alternatively to adding human capital as level we included the change in educational attainment, which - we remember - increased in general. In this specification (table 5, model (3)), all included factors become significant again. The coefficients of investment, of changes in the participation rate and of the spatial lag get again the order of the basic model. Changes in secondary level education seem to have a positive impact on growth, whereas – surprisingly – changes in higher level education have a negative impact. As a third possibility, human capital was included both in levels as well as a change (table 5, model (4)). Now we see that higher level educational attainment is important, both in levels and as a change, along with spatial lag of growth. All other factors, however, are not significant.

From this basic model, we can draw several conclusions with respect to the growth impact of human capital in Eastern European regions. First, higher level education was an important factor for growth, but an increase in tertiary level education in the population had a negative growth effect. An explanation may be that the increase of university education was a reaction of youths to avoid job search in a tight labour market and may at the same time have lowered participation rates so that it did not induce more growth. A more general interpretation may simply be that additional university education had decreasing returns since the level of higher education was already sufficient. A change in the structure of study disciplines may be yet another reason for the negative growth effect of increased higher education levels. Indeed, we find that the number of graduates from engineering and manufacturing went down in all countries. In Poland, also graduation in social sciences and business went significantly down in favour of humanities and education. In the Czech Republic and Hungary, however, we do not find this pattern, social sciences and business even increased. (OECD 1995-2000.) In summary, thus there was a certain shift to disciplines which do not contribute directly to productivity growth in the business sector. This may partly explain the negative growth effect of increases in higher education. Second, the relatively high medium level education rate in Eastern European regions seems to have had no significant effect on growth. This gives support to the possibility of a serious skill mismatch of educational standards and labour market requirements. However, changes of the secondary level education rate had a positive impact on growth. The generally slight increase of secondary education must have helped to upgrade skills.

The estimated coefficients for human capital are disappointing in view of the common support of the literature of the importance of human capital for growth. However, there is similarly puzzling evidence in the study of Campos and Kinoshita (2002) who investigated the growth impact of human capital (measured by the average number of years of schooling in the population) and found that it was negative in the period 1990-1998. They argue that human capital was artificially high in Eastern European countries, largely not coinciding with the actual qualification standards, and thus may not be such an important variable in the catching-up process.

Since the inclusion of human capital in levels clearly leads to a misspecified model because the coefficients are insignificant, we select the model with changes in human capital as the basic model for further estimations.

In the following we test for possible sources of technological progress: innovation, technology transfer and technology spillovers through FDI.

In table 6, starting from the basic model, the impact of innovation activity is tested. Three different indicators of innovation are checked: the absolute number of employment in the R&D sector, the share of labour force employed in R&D and the R&D expenditures to GVA ratio. In all estimations, R&D

has a positive sign but is statistically insignificant. If the share of R&D personnel is used, other coefficients as investment and changes in the participation rate become insignificant. A result which resembles the case of the level of higher education attainment rates. In fact, both the R&D labour force share and the higher level educational attainment rate are highly correlated with a factor of 0.88. Thus both variables capture innovation activity, as suggested in the growth model of Benhabib and Spiegel (1994). Further, both factors are particularly concentrated in capital areas. Thus they may actually capture the capital area effect which leaves other factors insignificant. (We shall see below with FDI that the capital area effect makes other variables such as FDI insignificant as well.)

The results of including innovation activity in the estimation suggest that, - irrelevant which indicator is used -, R&D does not seem to play a significant role for regional growth in Eastern Europe.

insert table 6 about here

As a second source for technological improvement, technology transfer was tested. Remember that a huge technological gap is considered as a high potential for technology transfer and therefore regions with a big technology gap should show higher growth. Contrary to that hypothesis, table 7 shows that regions with a high technology gap do not show the highest growth. However, if technology transfer is conditioned on the higher level educational attainment rate there is slight support for the proposed relationship, although the coefficient is not significant. The same does not apply for medium level human capital. Thus regions with a large technology gap would only benefit from technology diffusion if there is enough higher level educational attainment.

insert table 7 about here

In a next step, we analyse the possibility of technology spillovers through FDI, starting from our basic model (3) (see table (8)). First, we add the GVA share of FDI stock as a variable (model (11)) and find that the FDI stock has a paramount impact on regional growth in Eastern Europe. Regions which have twice as much FDI than others have almost 6 times higher growth rates while general investment has a much lesser impact on growth. Note that general investment includes private and public investment and of course also FDI (about 13 per cent of total investment). However, our FDI variable does not interfere with investment since the stock of FDI is regarded. A rise of the investment rate by one per cent increases growth only by 0.09 per cent. In model (12) and (13), the impact of FDI is conditioned on a region´s absorption capacity, given by the extent of medium level and higher level educational attainment. In both cases, the impact of FDI is significantly positive. Note that with model (12) and (13) FDI enters in an interactive term, therefore we cannot compare the size of the estimated coefficients with that of FDI alone. However, we can say that higher level education is more important for promoting spillovers than medium level education. We can conclude that human capital, particularly tertiary educational attainment, is important for drawing growth effects from FDI, but FDI by itself already promotes growth significantly.

In models (14) and (15) we checked if the significance of R&D and GAP would improve if considered together with FDI. The results show that, again, neither R&D nor GAP is significant. Consequently, we dismiss both variables as sources for technological progress.

insert table 8 about here

Next we consider the effect of geographical factors (see tables 9 and 10). If we include the market access variable, which should capture demand effects from national and EU centres, depending on their easiness of access, we get the strange result of a negative effect of market access. However, this requires more inspection. First, one has to be aware that our spatial lag model covers growth spillovers from surrounding regions. Second, the market access variable will only cover more distant demand if that is easily to be reached. If EU demand is too distant and transport linkages are bad that will not enter into access. Therefore it is very likely that the spatial lag and the access variable are correlated. Thus this may explain the negative coefficient. To check our argument, we can look at the coefficient of market access in the OLS estimation where spatial lags are not included. Indeed, the coefficient of access becomes positive, although statistically not significant, in the OLS estimation. (Note that the same story about the access variable appears not only in the basic model, but also in the extended model with human capital and FDI; see table 10, models (21) and (22).)

Thus we can conclude that market access is to some extent important for Eastern European regions, but that access to market demand is dominated by national centres and not EU centres to which transport linkages are still insufficient.

insert table 9 about here

In addition, we tested to which extent EU border regions and capital regions had a superior growth performance.

Why should EU border regions show a higher growth? Those regions changed from peripheral locations in the former socialist period to most advantageous locations, close to the EU markets. Many of them registered massive structural changes and are the destination of FDI, e.g. in Western Hungary (Nemes-Nagy (2000)). The geographical closeness to the EU means an advantage in transaction costs and we may expect that these regions also have a high share of export.

In many EU border regions, intensive cross border relationships have developed. Factor movements both of capital and of labour are very intensive. Thus it is not only big scale investment, which is oriented towards the border regions, but, in addition, firms from the neighbouring EU region would invest in smaller scale branches there, creating intensive cross border interactions and the possibility of technology and knowledge transfer. Similarly, labour market cross-border interactions are important. These regions are largely day to day commuting areas. A substantial share of the population receives higher wages from across the border which becomes extra revenue of the regional GDP, and again is also a source of knowledge transfer. Indeed, our estimation results indicate that the status of being a border region had a positive and mostly significant impact on growth (table 10, model (22) and table 10, model (23).)

Finally, if we look at the coefficient of capital area status, those are clearly growth leaders. Being a capital area largely makes other variables insignificant (see table 9, model (21) and table 10, model (24).

It should be noted, that coefficients of investment, of changes in higher level education, of FDI and spatially lagged income growth are fairly stable across different specifications. This suggests robustness of the results. By contrast, changes in labour force participation become less significant in more comprehensive models, which suggests that if other factors are present, they are more important for growth and negative consequences of declining participation rates affect growth less.

insert table 10 about here

In summary, we can draw the following conclusions:

(i) Our estimations suggest that the strong inflow of foreign direct investment played a paramount role for high growth in Eastern European regions. Regions with a two times higher FDI stock showed six times higher growth. Increased capital accumulation as such is far less important.

(ii) In addition to having a high stock of FDI, the fact of having the status of an EU border region was most influential for high growth in Eastern European regions. Being an EU border region improves growth by 1.3 per cent.

(iii) Further, there are significant spatial dependencies between closely located regions, so that a region´s growth is significantly more likely to be higher if being a neighbour of other high growth regions. About a fifth of a region´s growth is determined by that of surrounding regions. This indicates a tendency for growth clusters in Eastern Europe.

(iv) Being a capital area is more important then any other factor.

(v) The increase in tertiary education levels had a negative impact on growth, most likely because it lowered participation rates. Nevertheless, the estimations show that higher education per se is important for accommodating technology diffusion and technology spillovers from FDI in Eastern European regions.

(vi) The high level of secondary schooling among the Eastern European population has no influence on growth. This lends support to the argument that there is a serious skill mismatch between qualifications that once were acquired at school and those demanded by a restructuring industry.

(vii) The negative growth effect of falling participation rates, largely due to rising unemployment is lessened by the presence of other key growth factors.

(viii) Regions in Eastern Europe with an unfavourable location (Eastern border, internal regions), a low stock of FDI, a low level of higher education, no improvement of secondary education and high unemployment had no chance to catch up in income level in the period 1995-2000.

6. Conclusions

This paper wished to shed some light on the factors that determined regional growth in Eastern Europe in the second half of the 1990s, a period when transformation was largely settled and catching-up established to a quite different degree among Eastern European regions.

We set up our hypothesis on growth factors in an economic growth model and argued that the high observed capital accumulation and high educational level in Eastern Europe might have been important for growth in dynamic regions. Further we expected that technology transfer, in particular through FDI might have played an important role. In addition, we supposed that location factors and spatial dependencies mattered for growth.

The empirical analysis was done with a sample of 36 NUTS II level regions from the Czech Republic, Slovakia, Hungary, Poland and Slovenia for the period 1995-2000. To take likely spatial dependencies into account, we set up our growth regressions in a spatial econometric framework. It turned out that a spatial lag model, where per capita income growth is also dependent on growth of surrounding regions, would be most appropriate for our context. For estimation we used the general spatial two stage least squares procedure suggested by Kelejian and Prucha (1998), a two stage instrumental variable estimator which is considered as an unbiased estimator for the spatial context with established asymptotic properties.

Our results partly prove our proposed hypotheses, partly reveal new surprising aspects.

First, it was in particular foreign direct investment and not capital accumulation as such which was the main driving factor behind regional growth in Eastern Europe. Second, there are clear agglomeration advantages and better resources (human capital, research, FDI) in capital areas, which make those regions to growth leaders. In addition, EU border regions, where also a large share of FDI is registered and intensive cross border relations have established, generally could enjoy higher growth. The location advantage of closeness to EU markets benefits the EU border regions and puts other regions at a disadvantage. Third, we can observe regional clustering of growth, regions surrounded by high growth areas showed a high growth performance. However, as our experiments with market access measures and different spatial weights matrixes have shown, spatial effects were geographically rather limited, probably an evidence for insufficient transport infrastructures.

Evidently, own innovation activity still played an insignificant role for regional growth. By contrast technology transfer was the main source of productivity growth in Eastern European regions. Testing the technology gap model with human capital as a conditioning factor, we find that this was a likely way of technology transfer. Above all, however, FDI has to be considered as a main channel of technology spillovers, the more if combined with human capital of higher level education.

Surprisingly, the high ranking of Eastern regions with respect to secondary level schooling had no effect on regional growth, which suggests a problem of skill mismatch between qualifications acquired and those demanded in the labour market. Therefore our further result that improvements in secondary level education had a positive growth effect is not surprising. By contrast, the extent of higher level education proves to have been important for growth. It was essential for accommodating technology transfer and provides the pool for own innovation activity. However, the increase in higher education that took place did not benefit growth.

We should expect that regional disparities between Eastern European regions remain due to agglomeration forces and location advantages along the EU border. This calls for more concern about transport infrastructures to overcome location disadvantages. The education situation is much less satisfactory in Eastern European regions than considered at first sight. Improvement of qualifications and skills will become essential to meet the labour market requirements. Education will also be a key for attracting foreign direct investment, which will remain crucial for growth. These are big challenges for national policy makers and will need to be considered by EU regional policies.

APPENDIX

EAST RegStat

Data and definitions

36 NUTS II level regions from
Czech Republic, Slovakia, Hungary, Poland, Slovenia, time period 1995-2000

	DEFINITION	SOURCE
Gross Value Added	nominal and real GVA in Euro, at 1995 prices and 1995 exchange rates.	1995-1999 EUROSTAT. 2000 GUS, SURS, CSU, KSH and INFOSTAT.
Population	Total population.	CZ, HU, SI: 1995-1999 EUROSTAT, 2000 extrapolation. PL: 1995, 1998-1999 EUROSTAT, 1996 and 2000 GUS. SK: 1996-1999 EUROSTAT, 1995, 2000 INFOSTAT.
Employment	Total employment. Number of persons employed.	CZ and HU: EUROSTAT. PL: GUS. SI: SURS. SK: 1997-2000 INFOSTAT, 1995-1996 extrapolation based on GDP trend.
R&D expenditures	Total expenditures for research and development in business sector, government sector and higher education sector.	CZ: 1995-1997 EUROSTAT, 1998-2000 extrapolation. HU: KSH. PL: GUS. SI: EUROSTAT. SK: 1995-1997 EUROSTAT, 1998-2000 INFOSTAT.
R&D employment	Total employment in research and development in business sector, government sector and higher education sector.	CZ: 1995-1997 EUROSTAT, 1998-2000 extrapolation. HU: KSH. PL: GUS. SI: EUROSTAT. SK: 1995-1997 EUROSTAT, 1998-2000 INFOSTAT.
Gross Fixed Capital Formation	Gross fixed capital formation in Euro, at 1995 prices and 1995 exchange rates.	CZ: 1995-1999 EUROSTAT, 2000 allocation of country investment. HU: KSH. PL: 1998-1999 EUROSTAT, 1995-1997 and 2000 extrapolation, allocation of country investment. SI: SURS. SK: 1995-1999 EUROSTAT, 2000 from country data.
Foreign Direct Investment	Stock of foreign direct investment in Euro, at 1995 prices and 1995 exchange rates.	CZ: 1998-2000 CNB, 1995-1997 extrapolation based on allocation of country FDI stock. HU: calculated using regional data from KSH and allocation of country FDI stock. PL: calculated, based on regional FDI flows and allocation of country FDI stock. SI: WIIW. SK: 1996-2000 NBS, 1995 calculated from country FDI stock.
Education	Educational attainment. Number of persons who have completed secondary and higher level education. Secondary level education includes ISCED-97 sectors 3 and 4. Entrance is at age 15-16 after compulsory school. It comprises general education preparing for university entrance, vocational schools and also upper secondary level apprenticeship programmes of the dual system in Germany. Higher level education corresponds to ISCED-97 sectors 5 and 6. Sector 5 includes short degrees like bachelor (UK),	EUROSTAT Labour Force Survey for CZ: 1998-2000, HU: 1997-2000, PL: 1998-2000, SI: 1996-2000, SK: 1999-2000. Other years extrapolation.

education (cont.)	Fachhochschule (D) and laurea breve (I), but also longer higher education programmes like Diplom (D) and master (UK). Education in section 6 awards an advanced research qualification, like PhD programmes and doctoral studies. (See OECD, education at a glance 2002, Paris, OECD)	
Peripherality	European Peripherality Index EPI (market access indicator is the inverse function). The *market size* and the *distanc*e of the region of destination are taken into account. Market size is represented by regional population or GDP. Distance corresponds to travel time between two regions by different modes of transport.	Institute for Spatial Planning (IRPUD), University of Dortmund. For details see: Schürmann, C., Talaat, A. (2000)*: Towards a European Peripherality Index. Final Report*. Report for Directorate General XVI Regional Policy of the European Commission. Dortmund, IRPUD.

NOTES: CZ - Czech Republic, HU - Hungary, PL - Poland, SI - Slovenia, SK - Slovak Republic;

Data sources: CNB - Czech National Bank, CSU - Czech Statistical Office, EUROSTAT – Statistical Office of the EC, GUS - Polish Official Statistics, INFOSTAT Institute of Informatics and Statistics Slovakia, KSH - Hungarian Central Statistical Office, NBS - National Bank of Slovakia, SURS - Statistical Office of the Republic of Slovenia, WIIW - Vienna Institute for International Economic Studies.

List of variables used in the estimations

Äy	average growth of real GVA per capita, 1995-2000, in per cent
Äpart	average growth of participation rate (employment / population), 1995-2000, in per cent
inv	average investment rate (investment / GVA), 1996-2000, in per cent
RD_l	average R&D employment, logarithm, 1996-2000
RD_ls	employment in R&D in per cent of total employment, average 1996-2000
RD_e	R&D expenditures in per cent of GVA, average 1996-2000
hc_m	per cent of population (all ages) with secondary educational attainment in total population, average 1996-2000
Ähc_m	average growth of secondary educational attainment rate, 1996-2000, in per cent
hc_h	per cent of population (all ages) with higher educational attainment in total population, average 1996-2000
Ähc_h	average growth of higher educational attainment rate, 1996-2000, in per cent
GAP	productivity gap to EU average in 1995. GAP_i=(productivity $_{EU}$ - $productivity_i$)/$productivity_i$, whereby *i* indicates the region
*GAP*hc_h*	interaction term GAP and higher level educational attainment
*GAP*hc_m*	interaction term GAP and secondary level educaitonal attainment
FDI_s	stock of FDI in per cent of GVA, average 1996-2000
*FDI_s*hc_m*	interaction term FDI and secondary educational attainment rate
*FDI_s*hc_h*	interaction term FDI and higher level education
access_GDP	market access indicator, using GDP as measure for market size, ranges from 0-100, 100 = best access, derived from European Peripherality Index
access_POP	market access indicator, using population as indicator for market size, ranges from 0-100, 100 = best access, derived from European Peripherality Index
EU_border	dummy variable for EU border regions
capital	dummy variable for capital city regions

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Figure 1: Growth of gross value added per capita 1995-2000 and initial income of Eastern European regions

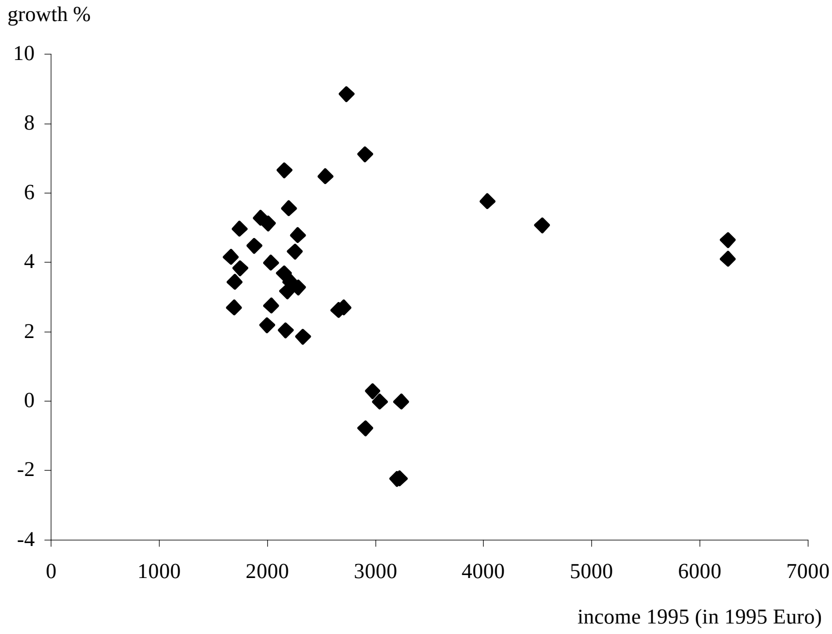

Table 1: Average growth of regional GVA p.c. in Eastern Europe 1995-2000 (in per cent)

	average	capital region	EU border regions	rest
Czech Republic	0.2	4.1	-0.7	0.0
Hungary	4.2	5.7	7.1	3.3
Poland	4.4	8.8	4.2	4.1
Slovenia*	4.6	-	-	-
Slovak Republic	4.2	5.0	5.0	3.9

*Notes: * Slovenia: national level; data sources: see Appendix*

Table 2: Average regional investment rate in Eastern Europe 1996-2000 (in per cent of GVA)

	average	capital region	EU border regions	rest
Czech Republic	31.7	43.7	30.8	29.3
Hungary	22.7	27.4	24.2	21.4
Poland	20.4	30.9	21.5	19.3
Slovenia*	28.4	-	-	-
Slovak Republic	39.8	74.7	74.7	28.2

*Notes: * Slovenia: national level; data sources: see Appendix*

Table 3: Average regional FDI stocks in Eastern Europe 1996-2000 (in per cent of GVA)

	average	capital region	EU border regions	rest
Czech Republic	26.2	59.5	21.7	21.3
Hungary	32.3	69.3	35.8	24.2
Poland	15.0	22.3	15.7	14.2
Slovenia*	15.1	-	-	-
Slovak Republic	10.7	25.3	25.3	5.8

*Notes: * Slovenia: national level; data sources: see Appendix*

Table 4: Human capital and innovation in Eastern Europe regions 1996-2000

attainment rate - secondary level education (in per cent of total population)

	average	capital region	EU border regions	rest
Czech Republic	55.8	56.2	55.0	56.3
Hungary	37.2	38.8	39.5	36.5
Poland	43.7	44.9	44.8	43.3
Slovenia*	43.3	-	-	-
Slovak Republic	48.5	49.2	49.2	48.3

attainment rate - higher level education (in per cent of total population)

	average	capital region	EU border regions	rest
Czech Republic	6.6	14.9	5.6	5.2
Hungary	7.0	12.1	6.8	6.0
Poland	6.1	9.3	6.1	5.9
Slovenia*	9.1	-	-	-
Slovak Republic	7.0	15.3	15.3	4.3

R%D expenditure (in per cent of GVA)

	average	capital region	EU border regions	rest
Czech Republic	1.3	2.4	0.4	1.6
Hungary	0.5	1.4	0.2	0.4
Poland	0.5	1.8	0.3	0.5
Slovenia*	1.6	-	-	-
Slovak Republic	0.9	1.5	1.5	0.7

*Notes: * Slovenia: national level; data sources: see Appendix*

Table 5: estimation results - basic model

dependant variable: Äy

	model (1)		**model (2)**		**model (3)**		**model (4)**	
intercept	-1.592	(-1.09)	0.247	(0.08)	-1.179	(-1.04)	-1.194	(-0.37)
inv	0.079**	(2.25)	0.001	(0.01)	0.115***	(3.99)	0.019	(0.45)
Äpart	0.302**	(2.24)	0.103	(0.79)	0.264**	(2.45)	0.072	(0.63)
hc_m			-0.055	(-1.07)			-0.010	(-0.16)
hc_h			0.427***	(2.77)			0.482***	(3.09)
Ähc_m					0.338**	(2.33)	0.218	(1.05)
Ähc_h					-0.348***	(-3.41)	-0.293***	(-3.04)
lag Äy	0.169***	(3.41)	0.157***	(3.83)	0.140***	(3.71)	0.138***	(3.92)
ñ$_2$	0.170		0.157		0.140		0.138	
z(I)	2.23		1.02		1.10		0.57	
LM_{ERR}	2.60		0.15		0.19		0.00	
LM_{LAG}	7.96***		7.43***		5.35**		7.41***	
adj. R^2	0.50		0.67		0.78		0.79	
no. obs.	36		36		36		36	

Notes: estimated using the general spatial two stage least squares procedure given in Kelejian/Prucha 1998, t-statistics in parenthesis, z(I) is the standardized z-value of Moran's I, LM_{ERR} is the Lagrange multiplier test for residual spatial autocorrelation, LM_{LAG} is the Lagrange multiplier test for endogenous spatial lag, *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

Table 6: estimation results - basic model and R&D

dependant variable: Äy

	model (3)		**model (5)**		**model (6)**		**model (7)**	
intercept	-1.179	(-1.04)	-5.028	(-1.68)	-0.614	(-0.48)	-1.350	(-1.18)
inv	0.115***	(3.99)	0.092***	(2.91)	0.065	(1.56)	0.093***	(2.86)
Äpart	0.264**	(2.45)	0.192	(1.64)	0.181	(1.55)	0.240**	(2.18)
Ähc_m	0.338**	(2.33)	0.271	(1.53)	0.292*	(1.83)	0.368**	(2.40)
Ähc_h	-0.348***	(-3.41)	-0.293***	(-3.10)	-0.324***	(-3.34)	-0.354***	(-3.51)
RD_l			0.520	(1.39)				
RD_ls					0.872	(1.52)		
RD_e							0.703	(1.32)
lag Äy	0.140***	(3.71)	0.140***	(2.99)	0.140***	(3.27)	0.150***	(3.85)
ñ$_2$	0.140		0.140		0.139		0.149	
z(I)	1.10		0.84		0.72		1.15	
LM_{ERR}	0.19		0.06		0.01		0.26	
LM_{LAG}	5.35**		4.14**		4.75**		5.90**	
adj. R^2	0.78		0.63		0.70		0.76	
no. obs.	36		36		36		36	

Notes: estimated using the general spatial two stage least squares procedure given in Kelejian/Prucha 1998, t-statistics in parenthesis, z(I) is the standardized z-value of Moran's I, LM_{ERR} is the Lagrange multiplier test for residual spatial autocorrelation, LM_{LAG} is the Lagrange multiplier test for endogenous spatial lag, *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

Table 7: estimation results - basic model and technology transfer

	dependant variable: Äy					
	model (8)		**model (9)**		**model (10)**	
intercept	1.4731	(0.81)	-1.3879	(-1.28)	1.8963	(1.07)
inv	0.0990***	(3.26)	0.0739	(1.38)	0.1139***	(4.01)
Äpart	0.1659	(1.40)	0.2203*	(1.90)	0.1655	(1.49)
Ähc_m	0.1570	(0.83)	0.2957*	(1.94)	0.1498	(0.93)
Ähc_h	-0.2476***	(-2.82)	-0.3387***	(-3.12)	-0.2518***	(-2.75)
GAP	-0.9773**	(-2.07)				
GAP*hc_h			0.0820	(1.02)		
GAP*hc_m					-0.0253**	(-2.41)
lag Äy	0.1669***	(3.42)	0.1370***	(3.95)	0.1437***	(3.48)
ñ$_2$	0.1669		0.1370		0.1437	
z(I)	1.04		0.94		0.70	
LM_{ERR}	0.19		0.94		0.01	
LM_{LAG}	5.55**		5.43**		5.68**	
adj. R^2	0.55		0.63		0.69	
no. obs.	36		36		36	

Notes: estimated using the general spatial two stage least squares procedure given in Kelejian/Prucha 1998, t-statistics in parenthesis, z(I) is the standardized z-value of Moran's I, LM_{ERR} is the Lagrange multiplier test for residual spatial autocorrelation, LM_{LAG} is the Lagrange multiplier test for endogenous spatial lag, *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

Table 8: estimation results - basic model and FDI

	dependant variable: Äy											
	model (3)		**model (11)**		**model (12)**		**model (13)**		**model (14)**		**model (15)**	
intercept	-1.179	(-1.04)	-2.162*	(-1.73)	-0.945	(-0.81)	-2.140*	(-1.76)	-2.199*	(-1.7)	-2.2091*	(-1.81)
inv	0.115***	(3.99)	0.081**	(2.70)	0.063*	(2.04)	0.081**	(2.67)	0.073**	(2.19)	0.0677	(0.39)
Äpart	0.264**	(2.45)	0.136	(1.20)	0.118	(1.06)	0.159	(1.41)	0.123	(1.06)	0.1313	(1.05)
Ähc_m	0.338**	(2.33)	0.086	(0.51)	0.126	(0.77)	0.215	(1.38)	0.081	(0.44)	0.1106	(0.65)
Ähc_h	-0.348***	(-3.41)	-0.280***	(-3.19)	-0.292***	(-3.46)	-0.314***	(-3.42)	-0.268***	(-3.07)	-0.2969***	(-3.16)
FDI_s			5.819**	(2.63)					5.565**	(2.35)	5.3801**	(2.36)
hc_h*FDI_s					4.832***	(3.04)						
hc_m*FDI_s							1.169**	(2.39)				
RD_e									0.278	(0.54)		
GAP*hc_h											0.0339	(0.47)
lag Äy	0.140***	(3.71)	0.198***	(4.36)	0.178***	(4.20)	0.195***	(4.43)	0.202***	(4.27)	0.1917***	(4.42)
ñ$_2$	0.140		0.197		0.179		0.195		0.202		0.1918	
z(I)	1.10		1.82		1.72		1.69		1.75		1.71	
LM_{ERR}	0.19		1.04		0.94		0.79		1.02		0.92	
LM_{LAG}	5.35**		7.80***		8.04***		7.48***		7.84***		7.87***	
adj. R^2	0.78		0.65		0.66		0.71		0.61		0.71	
no. obs.	36		36		36		36		36		36	

Notes: estimated using the general spatial two stage least squares procedure given in Kelejian/Prucha 1998, t-statistics in parenthesis, z(I) is the standardized z-value of Moran's I, LM_{ERR} is the Lagrange multiplier test for residual spatial autocorrelation, LM_{LAG} is the Lagrange multiplier test for endogenous spatial lag, *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.

Table 9: estimation results - basic model with geographical factors

dependant variable: Äy

	model (16)		**model (17)**		**model (18)**		**model (19)**		**model (20)**	
intercept	-1.592	(-1.09)	-1.966	(-1.17)	-1.644	(-1.06)	-2.282*	(-1.72)	-0.1708	(-0.12)
inv	0.079**	(2.25)	0.100**	(2.56)	0.085**	(2.43)	0.074**	(2.21)	-0.0052	(-0.14)
Äpart	0.302**	(2.24)	0.275*	(2.00)	0.316**	(2.37)	0.316**	(2.49)	0.1208	(1.01)
Ähc_m										
Ähc_h										
FDI_s										
access_GDP			-0.047	(-0.49)						
access_POP					-0.015	(-0.37)				
EU_border							0.929	(1.21)		
capital									3.5282***	(3.67)
lag Äy	0.169***	(3.41)	0.196***	(4.28)	0.187***	(3.74)	0.204***	(4.49)	0.1934***	(3.90)
ñ$_2$	0.170		0.196		0.187		0.204		0.1934	
z(I)	2.23		1.77		2.59		2.46		3.02	
LM_{ERR}	2.60		1.25		3.02*		3.05*		5.57	
LM_{LAG}	7.96***		6.74***		7.10***		8.48***		11.63***	
adj. R^2	0.50		0.56		0.55		0.61		0.50	
no. obs.	36		36		36		36		36	

Notes: estimated using the general spatial two stage least squares procedure given in Kelejian/Prucha 1998, t-statistics in parenthesis, z(I) is the standardized z-value of Moran's I, LM_{ERR} is the Lagrange multiplier test for residual spatial autocorrelation, LM_{LAG} is the Lagrange multiplier test for endogenous spatial lag, *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

Table 10: estimation results - extended model with geographical factors

dependant variable: Äy

	model (20)		**model (21)**		**model (22)**		**model (23)**	
intercept	-1.735	(-1.17)	-1.136	(-0.80)	-2.757**	(-2.32)	-1.309	(-1.07)
i	0.090**	(2.66)	0.093***	(3.07)	0.066**	(2.18)	0.014	(0.41)
Äpart	0.119	(0.99)	0.130	(1.16)	0.131	(1.21)	0.066	(0.65)
Ähc_m	0.091	(0.53)	0.015	(0.09)	0.083	(0.53)	0.131	(0.91)
Ähc_h	-0.281***	(-3.13)	-0.309***	(-3.43)	-0.287***	(-3.13)	-0.260***	(-3.11)
FDI_s	5.883**	(2.61)	5.622**	(2.54)	6.578**	(2.87)	3.392	(1.41)
access_GDP	-0.045	(-0.54)						
access_POP			-0.055	(-1.40)				
EU_border					1.295*	(1.99)	1.509**	(2.54)
capital							2.650**	(2.63)
lag Äy	0.191***	(4.12)	0.226***	(4.59)	0.229***	(4.97)	0.227***	(5.46)
ñ$_2$	0.191		0.226		0.229		0.227	
z(I)	1.73		1.92		1.91		1.71	
LM_{ERR}	0.73		0.91		0.99		0.69	
LM_{LAG}	7.14***		7.20***		8.12***		9.93***	
adj. R^2	0.66		0.70		0.77		0.81	
no. obs.	36		36		36		36	

Notes: estimated using the general spatial two stage least squares procedure given in Kelejian/Prucha 1998, t-statistics in parenthesis, z(I) is the standardized z-value of Moran's I, LM_{ERR} is the Lagrange multiplier test for residual spatial autocorrelation, LM_{LAG} is the Lagrange multiplier test for endogenous spatial lag, *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

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