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FDI, Human Capital and Income Convergence – Evidence for European Regions

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Abstract: This study examines regional GDP per capita income convergence for a sample of 269 regions within the European Union (EU) between 2003 and 2010. We use an endogenous broad capital model based on foreign direct investment (FDI) induced agglomeration economies and human capital. By applying a Markov chain approach to a new dataset that exploits micro-aggregated sub-national FDI statistics, the analysis provides insights into regional income growth dynamics within the EU. Our results indicate a weak process of overall income convergence across EU regions. This does not apply to dynamics within Central and East European countries (CEECs), where we find indications for a poverty trap. In contrast to FDI, regional human capital seems to be associated with higher income levels. Yet we identify a positive interaction of FDI and human capital in their relation with income growth dynamics.

Keywords: regional growth, convergence, FDI, human capital, European Union

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1. Introduction

Regional disparities in per capita output and income have been a concern of the European Community since its inception. The objective of reducing income inequalities has been challenged by the trade liberalization following the single market program and more enhanced by the continuous integration process of new member states. While economic growth and cohesion within the European Union (EU) tends to decreased income disparities on a national level, regional inequalities have rather deepened (Kramar, 2006). In this context, the convergence/divergence issue of per capita incomes across any set of regions in the EU has attracted considerable research interest in the last decade, but their results have been mixed. Some studies suggest the existence of convergence across all European regions (Fingleton, 1997, 1999; Lopez-Bazo et al., 1999; Votteler, 2004), while others show evidence of convergence clubs or multiple equilibriums within the income distribution (Lopez-Bazo et al., 1999; Ertur and Le Gallo, 2003; Canova, 2004; Le Gallo, 2004).

Within an endogenous growth framework (Romer, 1986; Lucas, 1988), the accumulation of foreign direct investment (FDI) can be regarded as an important growth driver that triggers technological progress, resulting in productivity spillovers. FDI has been perceived as a key ingredient for growth and catching-up strategies by Central and East European Countries (Campos and Kinoshita, 2002), which have designed policies that used various incentives to attract FDI (Rugraff, 2008). However, within CEECs the accumulation of FDI is spatially concentrated on capital regions (Gauselmann and Marek, 2012), which reinforces existing agglomeration economies but might potentially increase regional income disparities.

Already Griliches (1969) emphasized the complementarity between human capital and private physical capital that affects productivity growth. Human capital accelerates the rate of technological change through investments in education, workforce skills, scientific knowledge and social institutions (see Acemoglu, 1998, 2003; Benhabib and Spiegel, 1994, 2005; De la Fuente and Da Rocha, 1996; Nelson and Phelps, 1966). Arguably also regional growth differentials are determined less by the pure endowment of human and physical capital as growth factors than by the relation between these productive factors and their externalities (Klenow and Rodriguez-Clare, 2005; Mamuneas et al., 2006)

Against this backdrop, our paper contributes to the research long-term per capita income growth paths at the regional level. Thereby, we assess the individual relationships of FDI and human capital with income convergence dynamics as well as the existence of any complementarity between the two factors. This approach could highlight the existence of domestic and foreign led regional growth paths.

We investigate the association regional income growth dynamics for a sample of 269 European regions (NUTS2) during 2003 and 2010. We also analyze a sub-sample of 56 regions within CEECs for two reasons: Firstly, in order to scrutinize the catching-up process by CEEC regions compared to the whole EU sample, and secondly, to gain additional insights into the extent of endogenous growth in the new EU member countries. Since regionally disaggregated FDI statistics are not available for the EU, we exploit information using a novel micro aggregated dataset. We apply a Markov-chain approach to examine income distribution dynamics. Through the estimation of transition matrices, it can be scrutinized whether regions of a certain income class move along the income distribution or remain in their income class Research on regional convergence emphasizes the importance of capturing intra-distribution dynamics, since the relative position of regions can change over time (Quah, 1996a; 1996b; 1996c; 1996d; 1997).

The structure of this study is organized as follows: section 2 reviews the economic theory of regional convergence in GDP per capita income, with an emphasis on the role of FDI and human capital. In addition, we provide an overview of the state-of-the-art in European convergence, including an outline of the role of FDI in regional economic performance as well as an introduction to the Markov chain approach. Section 3 introduces the dataset employed. Section 4 presents the results from the empirical investigations, which are discussed in more details in section 5. Section 6 provides conclusions.

2. Theoretical framework

In standard Solow-type neo-classical growth models with diminishing returns to capital, an exogenous increase of FDI extends the amount of capital and income per capita only temporarily, while diminishing returns have only short-term growth effects towards a steady state. The impact of FDI on long-term growth rates in this model is determined solely by the exogenously given technological processes in economic growth. Endogenous growth models (Romer 1986; 1994; Lucas 1988) identify innovation, invention and creation as the main engines of growth. The growth dynamics of the endogenous models are generally characterized by the assumption of constant returns to the set of reproducible factors in the production function.

According to Martin and Sunley (1998) endogenous broad capital models introduce two explanations for FDI promoted long-term growth in a host economy. The first subset of endogenous broad capital models is based on external economies associated with FDI agglomeration. Already the classical foundations of endogenous growth models (Arrow, 1962; Romer. 1986) stress the role of spatial externalities including disembodied knowledge diffusion. The new economic geography (Krugman, 1991) further emphasizes that increasing returns to physical capital are geographically localized. Agglomeration economies related to geographical proximity and the pooling of production factors as describe by Marshall (1890) may stimulate the attraction of FDI. Related empirical evidence already established the relevance of agglomeration economies and externalities as factors which explain foreign firms' sub-national location pattern in the EU (Basile et al. 2008; Cantwell and Piscitello, 2005; Mariotti et al., 2010).

In principle, there exists a consensus that FDI can contribute to the long-run income growth through productivity effects and technological spillover (see Görg and Greenway, 2004, for an extensive review). The value adding content of FDI-related productivity spillover could affect regional income growth in two ways: First, through vertical linkages of foreign firms with domestic firms, which trigger closer client and supplier relationships and spillover (Hirschman, 1958; Markusen and Venables, 1999). Second, foreign firms might trigger horizontal spillover to domestic firms within the same industry, since local firms could benefit from demonstration effects (Mansfield and Romeo, 1980; Dunning, 1993). The existing research on FDI productivity externalities at the sub-national level in Europe also indicates, that that intra-industry and inter-industry spillover have a strong localized dimension (Girma and Wakelin, 2007; Mariotti et al. 2015).

Most of the existing studies investigate the effect of FDI accumulation on economic growth at the country level and they identify a positive relationship (see e.g. Carkovich and Levine, 2002; Ozturk and Kalyoncu, 2007; Mallick and Moore, 2008). So far we have limited knowledge to which extent this applies to the sub-national level too. Therefore, this study investigates the relationship between FDI and long-term income growth rates within the EU at the sub-national level of analysis. We hypothesize that:

(1) *The agglomeration of FDI within regions is positively associated with long-term income growth rates.*

Findlay (1978) suggests a model that endogenizes the rate of technical change in a backward region as a function of is exposure to foreign capital. Thereby, the potential for technological diffusion via FDI is positively related to the relative technology gap between the home and host economy. Findlay refers to the ‘contagious effect’ where technical innovations are most effectively copied when there is personal contact between those who have already knowledge of the innovation and those who eventually adopt it (Nelson, 1968; Mansfield, 1961; 1968). Furthermore, Findlay’s model refers to the concept of relative backwardness as developed by Veblen (1915) and Gerschenkron (1962). Both argued that the larger the disparity in income levels between an industrialized country relative to an industrializing country, the larger the potential rate of catch-up growth for the latter. If the technology gap hypothesis holds, we could expect that:

(1a) The agglomeration of FDI within regions is positively associated with catching-up of regions at the lower end of the income distribution.

The second subset of broad endogenous capital models are associated with the complementarity of production factors, in particular human and physical capital. In this approach human capital is an endogenous driver of technological progress (Romer, 1990; Aghion and Howitt, 1992). If technological change is linked to intensive investment in physical capital related to a qualified workforce, there arise opportunities for “learning by doing” and “knowledge spillovers” (Romer, 1990). Thus, a higher level of human capital is expected to stimulate the economic growth of via increasing returns on physical capital. Greater human capital endowment favors the absorption of technology, accelerating the rate of technological change (Nelson and Phelps, 1966; Barro, 1991; Benhabib and Spiegel, 1994; Acemoglu 1998; 2003).

Following Mankiw et al. (1992), FDI is assumed to be more productive than domestic investments since it encourages growth by the incorporation of new technologies (i.e. R&D and human capital) in the production function of the host economy. In turn, Barro (1991) holds that a higher level of education increases the capacity to adopt foreign technologies and thus reduces the “knowledge gap” between countries. Thus technologically backward countries may be able to catch up, if they have a tock of well educated workers (see e.g. Nelson and Phelps, 1966; Benhabib and Spiegel, 1994). Following this line of reasoning Keller (1996) and Borensztein et al. (1998) suggest that the application of more advanced foreign technologies requires the presence of a sufficient level of human capital in the host economy. Thus, in contrast to the technology gap hypothesis FDI induced catch-up growth might be conditional upon human capital endowment.

Empirical evidence demonstrates for EU sub-national regions that a higher share of educated workers in the labor force is positively associated with higher regional income growth (Cuaresma et al, 2014). The importance of human capital is especially strong for regions with capital cities and this effect is particularly sizable in CEECs (ibid). This coincides with the observation that FDI is highly concentrated in capital cities of CEECs (Gauselmann and Marek, 2012). Kottaridi (2005) analyze the FDI-related growth patterns for two samples of broadly defined 'core' and 'periphery' regions in Europe. The results indicate that FDI and human capital agglomeration economies play a significant role for growth in core regions, while these factors are not capable to boost growth in peripheral regions.

In continuation of these findings, this study contributes by investigating the individual relationships of FDI and human capital with income convergence dynamics across EU regions as well as the existence of any complementarity between these two factors in line with broad endogenous capital models. Thus, we hypothesize that:

(2) Human capital and FDI agglomeration within regions positively interact in their relation with long-term growth rates and catching-up of regions at the lower end of the income distribution.

3. Research method and data

3.1 The Markov chain approach

The traditional concept of income convergence originates from a neoclassical growth model. In the literature, the concepts of β- and σ-convergence (see e.g. Barro and Sala-i-Martin, 1991a; 1991b; 1995) have evolved as a benchmark for the analysis of income convergence. In these frameworks, the convergence coefficient describes an average convergence behavior. In order to gain additional insights on the convergence dynamics of the entire sample, Quah (1993a; 1993b) introduced an approach basing the non-parametric Markov chain method with a focus on the movements of regions along the income hierarchy. For this purpose, the sample is split into several income classes. The Markov chain approach draws upon the probabilities to move along the income hierarchy between two periods of time (Rey, 2001), which are calculated with respect to the distribution of regions across income hierarchies in two periods of time.

The estimated transition matrix is assumed to be memoryless and time invariant. Therefore, Quah (1996a) holds that the Markov chain method is more flexible than the neoclassical growth models. Furthermore, Fingleton (1997) emphasizes that the Markov chain approach may account for regional specific income dynamics rather than the smooth progression of a steady state implied by the neoclassical approach. For the investigation of the relationship between FDI and income convergence, this paper follows the studies of Bickenbach and Bode (2003) and Bode and Nunnenkamp (2010), who used the Markov chain method in order to analyze the effect of FDI on income growth for US regions.

In order to investigate the income growth dynamics across $r \in R$ European regions, we consider a finite first-order Markov chain with stationary transition probabilities. At each point in time *t* (= 0, 1, 2,…), the income per capita values determine the division of the sample's regions *r* (= 1, 2,…, R) into *N* ordered and non-overlapping income interval classes. By definition, $s_i(t)$ denotes the share of the sample's regions belonging to income class *i* (ϵ *N*) at time *t*, where $s_i(t) \geq 0$ and $\sum_i s_i(t) = 1$.

The calculation of the transition matrix is based on the movement of the sample's regions along the income hierarchy from income class *i* at time *t* to income class *j* (ϵ *N*) at time *t+1*. Hence, the transition matrix consists of N^2 elements, while the elements of row *i* represent the transition probability of a region in income class *i* at time *t* to become a member of income class *j* at time *t*+1, $p_{ij}(t)$ with $j \epsilon N$, $p_{ij}(t) \geq 0$ and $\sum_j p_{ij}(t) = 1$.

In order to identify a process of convergence or divergence in GDP per capita among European regions and separately for the CEEC regions, the dataset is separated into the sub-samples $m \epsilon M$ (=1, 2). The first sub-sample investigates convergence among all European regions, while the second contains the regions from CEECs. Due to the focus on the development of CEE regions after their accession to the European Union, we chose the year 2003 as the initial year, *t*, and the year 2010 as the subsequent point in time, *t+1*.

Following the *law of motion* used by Quah (1993b), it is typically assumed that the transition probabilities are time homogenous of order 1, such that $p_{ij}(t) = p_{ij}$ is considered for all *t*. By satisfying this relation for all classes, regions and points in time, the process can be called a discrete Markov chain and simply means that the probability of a region being in a certain income class *j* depends only on its present situation *i* (at time *t*). Correspondingly, the transition probability of a region is independent of the past history of the region, what is typically called the Markov property (Geppert and Stephan, 2008). However, the further derivation of time-homogeneity by the *law of motion* states that there is an *N x N* row standardized transition matrix Π_M, which reports the transition probability of elements p_{ij} in each cell, such that the regional income distribution at time *t* is given by the row vector $S(t) = (s_1(t), s_2(t), \ldots, s_n(t))$. Under these conditions the process of transition between regional income classes $S(t+1)$ at time *t*+1 can be described as:

$$S(t+1) = S(t)\Pi_M = S(0){\Pi_M}^t. \quad (1)$$

Since the Markov chain process can be considered to be time-invariant, the $(N \times N)$ transition matrix Π_M can, with regard to above conditions, be formally noted as:

$$\Pi_M = \begin{bmatrix} p_{11|M} & p_{12|M} & \cdots & p_{1N|M} \\ p_{21|M} & p_{22|M} & \cdots & p_{2N|M} \\ \vdots & \vdots & \ddots & \vdots \\ p_{N1|M} & p_{N2|M} & \cdots & p_{NN|M} \end{bmatrix} \quad (2)$$

summarizing all N^2 transition probabilities $p_{ij|M}(i,j = 1,\dots,N)$. In illustration, the second row of the transition matrix indicates the probability that a member of the second income class (i=2) will stay in the same class (p_{22}), descend into the lowest income class during one transition period (p_{21}), move up into the next income class (p_{23}) or possibly move two classes upward (p_{24}). If a region has once moved to another income class, it will behave according to the transition probability relevant to that class.

One of the major issues in estimating transition matrices relies on the concept of defining the per capita personal income classes (PCPI) as outlined by Geppert and Stephan (2008) or Eckey and Türck (2006). For the purpose of this study, we split the sample regions into N=5 income classes. For the initial year 2003, each income class is equally sized. Hence, the choice of the threshold levels is determined by the distribution of the income per capita across the sample's regions. In the complete EU sample, the first income class comprises the poorest regions with a PCPI of below 11,150 € and the highest income class comprises those regions with an average PCPI of above 26,750 €. The mean per capita income class falls into the third group, and ranges from 18,800 € to 21,400 €.

In order to account for the average growth rate in the sample regions, the threshold levels for the period 2010 are defined by multiplying the initial threshold levels with the average growth rate of the regions in each (sub-)sample. In this concept, the move of a region to an upper/lower income class indicates that the region has experienced an income growth rate above/below average in comparison to the average regional growth rate.

Following the study by Bode and Nunnenkamp (2010), this analysis investigates the relationship between FDI and human capital by splitting each (sub)-sample with respect to the median regional endowment with FDI and/or human capital. This procedure allows us to investigate whether the endowment with FDI and/or human capital has an impact on the income convergence process in the regions of our sample.

To sum up, the transition probability matrix provides a well suited non-parametric approach in providing a more detailed insight into the entire income distribution within a system of regions. The discrete approximation of cross-sectional distributions determines N^2 transition probabilities, which form a matrix Π_M. This matrix exploits information on the regional dynamics of the income distribution of the sample in several ways: Firstly, the transition matrices offer a concrete probability of whether a region of a certain class will move to other income classes in the given time horizon. Secondly, by providing a regular transition matrix, the assignment of the limiting distribution can reveal whether a process of convergence or divergence exists across the economic system.

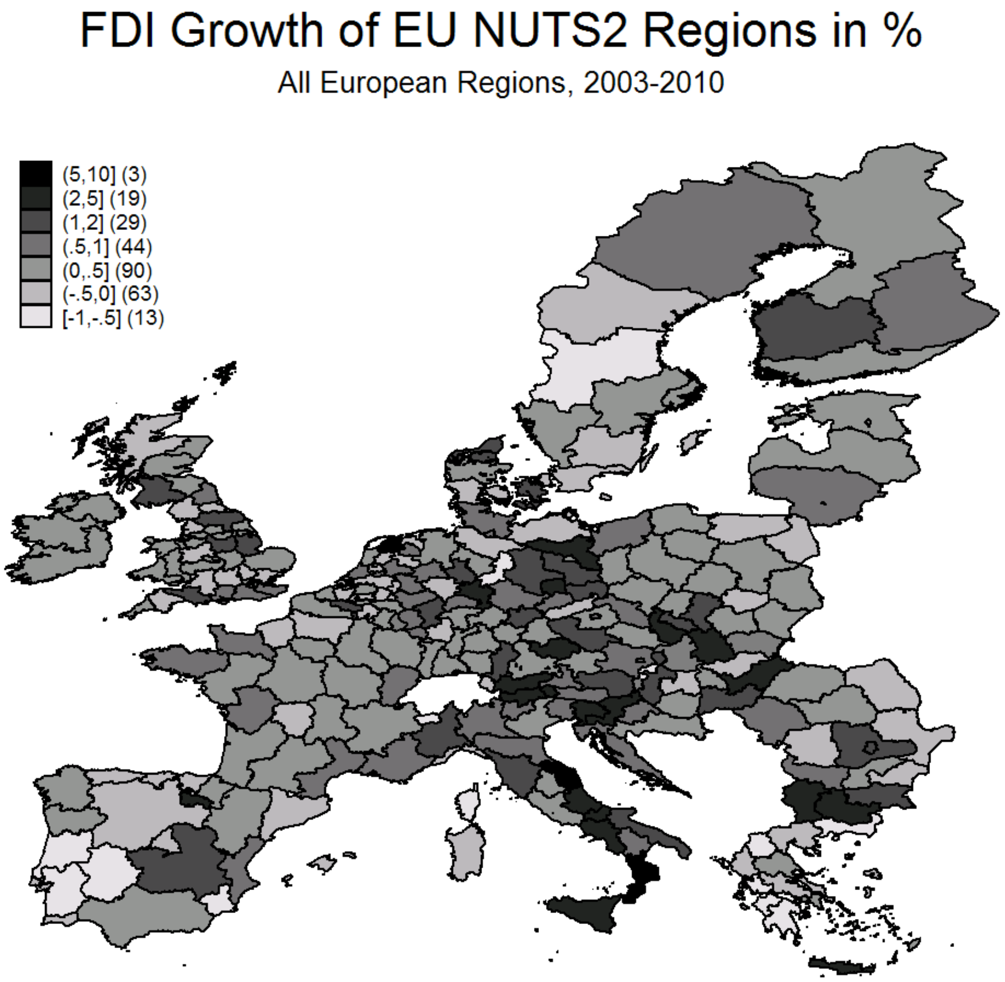
A number of authors (e.g. Fingleton, 1997; Magrini, 1999; Geppert and Stephan, 2008) note that the causal inferences drawing on the limiting distribution should be treated with some caution. In particular, the assumption of ever constant transition probabilities is not backed up by any empirical evidence. Instead of interpreting the limiting distribution as a definite forecast of long-term growth, it should be rendered rather as a hypothetical situation that will occur if the regional income patterns observed in the past persist. In this regard, the results obtained from the limiting distribution in the analysis will in the first place provide information on the period from 2003 to 2010 and the near future, but not conclusively on long-term developments.

In contrast to the neoclassical model and convergence regressions, the Markov chain method is a descriptive procedure to investigate the income dynamics across regions. Hence, it does not explicitly allow conclusions on the causality on the income convergence (or divergence) of regions in a given sample. Yet, we implement an implicit causality analysis by splitting the regional (sub-)sample(s) into additional subsamples with respect to the regional endowment with FDI and/or human capital. This procedure allows us to analyze the convergence dynamics of the entire sample with respect to the importance of foreign physical capital and human capital. In the case that the transition matrices differ substantially across the subsamples with respect to the regional endowment with FDI and/or human capital, this approach would enable us to draw implicit conclusions on the role of FDI and/or human in the context of income convergence.

3.2 Data

We employ information from 269 EU regions to analyze the effect of foreign physical capital accumulation and human capital on regional GDP per capita growth within 26 countries of the EU from 2003 to 2010.1 Balance of payment data on FDI is not available in a regionally disaggregated form. We follow an alternative strategy by generating a micro-aggregated dataset based on information on the stock, employment and turnover of firms, which can be regionalized based on exact information on the firm location (see Capello et al 2011; 2013 for a similar approach).

Figure 1: FDI growth of all EU NUTS2 regions from the sample in %: 2003–2010



Source: Own estimations from the sample data, obtained from AMADEUS Database

The firm-level data is drawn from Bureau van Dijk's AMADEUS Database, which allows the identification of assets that are owned by non-residents. A resident enterprise is considered to be foreign owned if a foreign shareholder holds at least 10% of the direct

[1] Malta and Cyprus are excluded because of their small sample size.

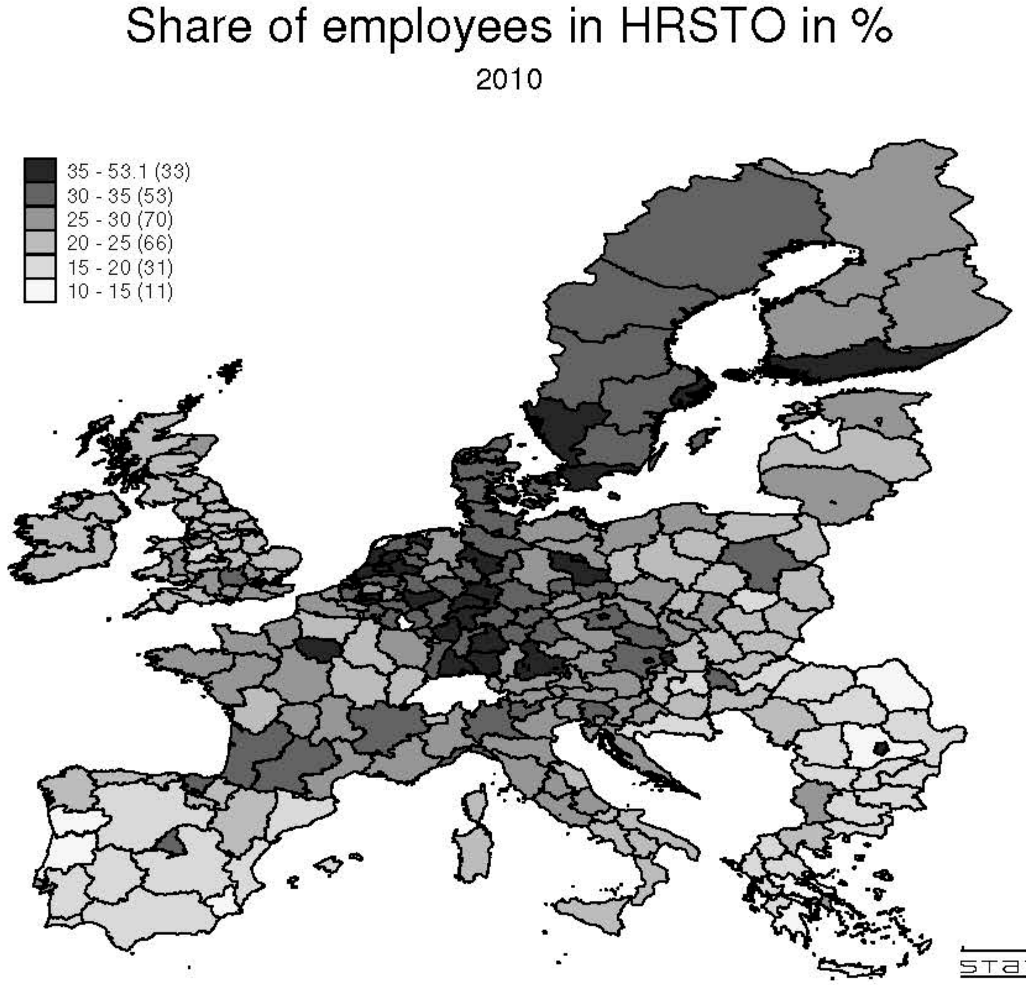
shares/voting rights or if the ultimate owner is foreign. In order to avoid the oversampling of firms from selected countries resulting from country specific differences in coverage, we include in the final sample only firms with at least 10 employees. The final firm-level sample consists of 26 EU countries, including 11 CEECs (Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia). The location of firms is disaggregated by the Nomenclature of the Territorial Units for Statistics of level two (NUTS2). The full sample includes 787,097 foreign firms located in 269 NUTS2 regions.[2]

Figure 1 indicates the relative growth rates of FDI stocks in terms of turnover generated by foreign firms during the observation period of 2003 to 2010. We find positive growth rates in foreign turnover in 185 regions. Whereas the growth in foreign turnover in Western Europe tends to be spread more evenly across all regions regardless of capital regions (excluding Spain and Portugal), the opposite seems to be true for CEECs. Growth in foreign turnover in the new EU member states seems to be largely concentrated in Bulgaria, Hungary, Slovenia and Slovakia, and to a lesser extent in Poland and Romania. As with findings from other studies (Casi and Resmini, 2010; 2012), the capital and border regions of the CEEC states reflect a significantly more intensive growth than the rural regions.

Our analysis exploits additional regional data to capture the human capital endowment across EU regions. In particular, we draw upon information about human resources in science and technology (HRSTO), which are defined according to the Canberra Manual (OECD, 1995) as persons having graduated at the tertiary level of education or employed in a science and technology occupation for which a high qualification is normally required and the innovation potential is high. While tertiary level graduates give a measure of supply of skills, demand for skills of workers is better gauged by occupations. Human resources in science and technology are defined on the basis of both educational attainment and occupations. This might be particularly relevant in order not to overestimate human capital endowment in CEECs, where formal education levels have been partially depreciated by the transition process. In addition, HRSTO captures the technological skills of the regional workforce. Thus, this indicator seems appropriate to capture the human capital-related aspect of technological accumulation in parallel to capital accumulation across EU regions.

[2] For a detailed insight into the total amount of FDI companies located over the time period 2003-2010 in each country, as well as for the EU-15 and 11 CEEC regions see Table A3 in the Annex.

Figure 2: Share of employees in HRSTO in %: 2010

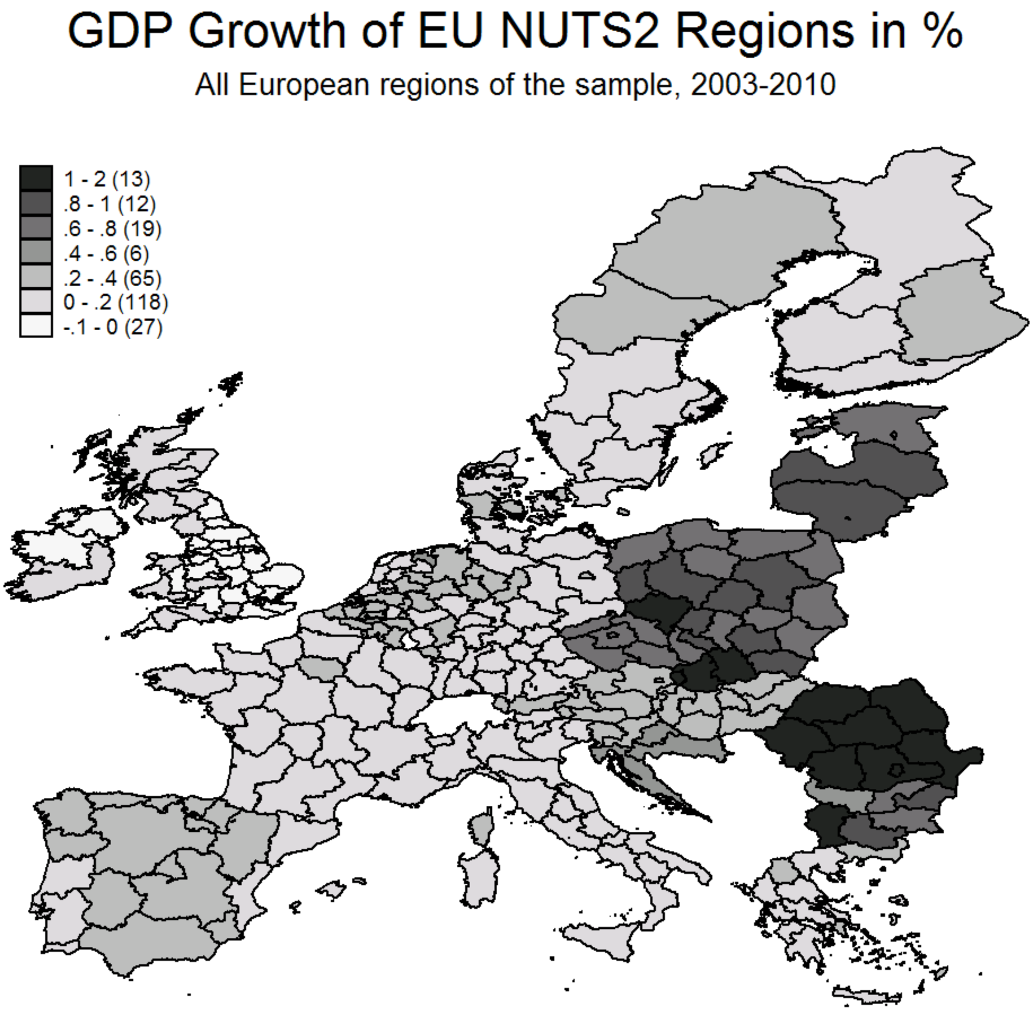


Source: obtained from Eurostat.

Figure 2 shows considerable heterogeneity of HRSTO endowment within and across EU countries. There seems to be no clear pattern of an East-West divide, since NUTS2 regions within CEECs can be compared to human capital levels in selected EU15 regions. Regions with capital cities and regions in proximity to those are comparable to EU15 regions with the highest share of employees in HRSTO.

Our investigation relies also upon information on the regional income rates at NUTS2 level. The GDP per capita is calculated using population and income data collected by EUROSTAT and is expressed in Purchasing Power Standard (PPS) in order to take the differences in national price levels into account. Figure 3 summarizes the development of GDP per capita growth for all European regions over the time period 2003 to 2010.

Figure 3: GDP growth of all EU NUTS2 regions from the sample in %: 2003–2010



Source: Own estimations from the sample data, obtained from EUROSTAT Database

Economic growth dynamics have been positive for all Western European regions, which experienced a growth in income of up to 40% over the observation period. Exceptions are negative growth rates for the UK regions. Special attention can be turned to the regions in CEECs, which show an aggregate growth of more than 40%. A remarkably strong concentration of growth (between 100 and 200%) in per capita GDP can be identified in all regions of Slovakia and Romania and also, to some extent, in Croatia, the Czech Republic, Poland and the Baltic states.

4. Estimation results

4.1 Income convergence

First we examine the income convergence in the EU-27 and CEECs regions. Table 1 depicts the Markov transition matrix, Π_M in equation (2), for the entire sample of 269 EU regions in terms of their levels of GDP per capita growth. This table also indicates the initial distribution, s (t) in equation (3), in terms of absolute and relative frequencies (two columns labeled "initial distribution"), as well as the converging limiting distribution of the Markov chain (s* in equation (4.4), row labeled "limiting").

Table 1: Evolution of income distribution across EU regions, 2003–2010

PCPI class	initial distribution		final distribution				
	N	%	1	2	3	4	5
1	53	19,70	94,34	5,66	0,00	0,00	0,00
2	54	20,07	1,85	88,89	5,56	3,70	0,00
3	52	19,33	0,00	28,85	61,54	9,62	0,00
4	56	20,82	0,00	1,79	35,71	55,36	7,14
5	54	20,07	0,00	0,00	0,00	16,67	83,33
limiting	269	100	18,96	24,91	20,45	17,47	18,22

Source: Own estimations from the sample data

The initial distribution shows a fairly even distribution of observations across all five income classes, considering class 3 as the middle income class. The comparison of the initial and the limiting distribution indicates a rather weak tendency of income convergence across the whole sample of European regions between 2003 and 2010. The limiting distribution shows a slightly higher concentration in the middle income class, and lower concentrations in the extreme classes 1 and 5.

The comparison of the initial and the limiting distribution in the income classes shows only small differences of about five percent, indicating that the income distribution across all EU regions is already close to its steady state. However, the estimated transition matrix offers several detailed insights into the dynamics of this convergence process. Table 1a indicates that the below-average income classes (levels 1 and 2) face only small, but upward moving transition probabilities of about 5 to 10 percent of movement on the income ladder. In contrast, the higher income classes (levels 4 and 5) show a lesser degree of stationary probabilities and thus face higher transition probabilities of moving down than of moving up in the income distribution. The regions of income level 4 face a probability of 37,5 percent (35,71+1,79; second and third value of line 4) of relegation and a fairly low stationary probability of remaining in the level (55,36 percent).

These estimation results reveal a weak tendency of GDP per capita convergence across all European regions. The specific distribution dynamics show on average that below income classes were exposed to higher growth rates than higher income classes. To sum up, this could hint at an income convergence process across EU regions with limited catching-up by regions at the lower end of the European income distribution.

A closer look at the type of regions that reflected at least one level of growth shows that out of a total of 17 regions, nine can be identified as European capital cities (see Annex Table A6a). Even more remarkably, this includes the three capital regions of the Czech Republic, Romania and Slovakia.

We turn now to growth dynamics in the sub-sample of EU regions in the 10 CEECs during the observation period of 2003 to 2010. The initial distribution in Table 2 indicates – as in case of the EU26 – a fairly even distribution of regions across the five income classes. However, the limiting distribution differs significantly from the initial distribution, especially in PCPI classes 1 to 3. While the limiting distribution of income classes 2 and 4 increases around the middle income class 3, the lowest income class 1 and the middle income class 3 decrease considerably. This implies a concentration of CEECs regions at both extreme ends of the limiting income distribution and a decreasing middle income class.

Table 2: Evolution of income distribution across CEEC regions, 2003–2010

PCPI class	initial distribution		final distribution				
	N	%	1	2	3	4	5
1	11	19,30	63,64	36,36	0,00	0,00	0,00
2	9	17,55	0,00	77,78	22,22	0,00	0,00
3	12	21,05	0,00	16,67	50,00	25,00	8,33
4	12	21,05	0,00	15,38	7,69	69,23	7,69
5	12	21.05	0,00	0,00	0,00	16,67	83,33
limiting	56	100	12,28	26,32	15,79	24,56	21,05

Source: Own estimations from the sample data

While the Markov approach identifies a process of convergence if $s_M^* > s_M(0)$ in the median class and $s_M^* \leq s_M(0)$ in the higher and lower income classes (suggesting the opposite development for divergence), the comparison of initial and limiting income distribution exhibits no evidence of convergence or divergence in the group of CEEC regions. The middle income class shrinks significantly, while its probabilities of moving up are higher than of moving down in the income distribution. Higher frequencies in the lowest and highest classes would indicate divergence, but the final distribution in the lowest income class decreases whereas the regions of the highest income class 5 remain with an unchanged probability. The concentration of regions in income classes 2, 4 and 5 suggests the existence of a poverty trap rather than a divergence.

When considering the explicit distribution dynamics of regions, the transition probabilities also indicate accumulation at both ends of the income distribution. While the PCPI classes 2, 4 and 5 show high stationary probabilities of remaining in the same class (up to 70 percent), regions in the middle income class 3 face a 50 per cent possibility to of remaining stable as well as a 17 per cent and 33 percent possibility of moving downwards – or upwards – respectively. The considerable decline of regions in the first and third PCPI class contributes to the notion of two peaks in the income distribution.

The most striking inference to be drawn from the estimated CEEC transition matrices is the high persistence of income classes at both ends of the income distribution. Even if the results from Figure 3 suggest that CEEC regions commonly enjoy higher GDP per capita growth rates than the EU-15 regions, the results on the evolution of the per capita income distribution do not offer much evidence for the existence of a "convergence club" in the CEEC as a whole. Since the middle income class vanishes and regions accumulate with a strong persistence at both ends of the income distribution, we can talk of a poverty trap for "poor" and lagging-behind CEEC regions.

If we now take a look at the type of regions with particular levels of growth over time (see Annex Table A6b), we can see that 21 CEEC regions have grown by one level of growth and seven by two levels. In contrast to the above findings for the EU sample, we find no capital cities, since capital regions in CEECs are already in the highest PCPI income class. These findings further strengthen the notion of poor regions that have in fact grown by one level, but still remain in the lower PCPI classes 1 to 3 and face only minor transition probabilities of catching up. Furthermore, we see that most of the regions in Poland and Romania have grown only within the PCPI income classes 1 to 3. More specifically, this is true for almost all Romanian regions (except capital city region RO32) and for all four Polish regions from region PL3. Surprisingly, almost all Bulgarian regions (except capital city region BG41) have remained in the lowest income class while almost all Hungarian regions (excepting capital city region HU10 and the western border region HU21) have fallen back by one level of growth to PCPI income classes 1 to 3.

4.2 FDI stocks and changes to the income distribution

In order to identify the impact of FDI stocks on GDP income growth rates, the density of FDI stocks in a region will be measured by two indicators: a) the share of foreign generated turnover and b) the share of foreign employees per region. The latter measure takes account of the relative size of foreign owned firms in a region. This measure also eliminates potential bias resulting from the many small foreign owned firms in border regions between CEEC countries. For the extensive consideration of FDI stock densities by the share of foreign turnover and employees, the sample of each indicator will be further separated into EU and CEECs sub-samples. Following Bode and Nunnenkamp (2010), the differentiation of the samples is defined by the median FDI density of regions in the first year of the observation period (2003).[3] This distinction permits a direct comparison of the sub-samples in order to verify a positive association between FDI densities and income growth levels.

Estimation results for EU sample

First we analyze the relationship for the whole sample covering all EU regions by measuring the FDI stock density in terms of foreign generated turnover (see Annex Table A4a). The initial distribution indicates that regions with an above average FDI density were already richer at the outset. The probability of starting from one of the two highest PCPI classes is about 44 percent for regions with a high density of foreign turnover and 38 percent for EU regions with a lower density.

The limiting distributions indicate that EU regions with an above average density of foreign turnover will tend, on average, to be richer in the long term than regions with a lower than average density of FDI stocks. The probability of ending up in one of the two highest income classes is about 40 percent for regions with a high density of foreign generated turnover, but only 33 percent for regions with a below average density of FDI stocks. However, the estimated transition probabilities of the limiting distribution reveal no evidence of a significant positive association of FDI stocks with long-term growth. While the sample of regions with an above average density of FDI stocks faces a higher probability of ending up in the two highest PCPI classes, these regions also face a similar probability of 40 percent of ending up in the lowest PCPI classes of the sub-sample with high FDI stocks. In contrast, the probability of regions in the below average FDI density sample ending up in PCPI classes 1

[3] The median of the sample in all European regions is19,95% in the case of foreign generated turnover and 13,94% in the case of foreign employees. Correspondingly, the median for the CEEC subsample is 22,41% in the case of foreign generated turnover and 14,29% in the case of foreign companies.

and 2 is higher (48 percent) than their ending up in classes 4 and 5 (33 percent). An additional comparison of the two samples of FDI stock densities in terms of generated turnover reveals that the PCPI classes in the below average FDI stock sample face much higher stationary probabilities of remaining in their income class than regions from the above average FDI stock sample, which show lower stationary probabilities by comparison but therefore higher distributional dynamics in the income distribution.

In the case of the sample of European regions measured in terms of FDI employment density (see Annex Table A5a), the findings corroborate the above estimations of FDI stocks in terms of foreign generated turnover. The results of the initial and limiting distributions of FDI employment draw a fairly similar picture of very limited positive effects on GDP per capita growth rates, while EU regions from the above average FDI density sample indicate a fairly equal probability of ending up in the two highest or in the lowest PCPI classes. Moreover, the estimated relationship between FDI employment and income dynamics is inverted if the FDI density is measured at the below median sample. The results of the limiting distribution indicate that the lowest income classes 1 and 2 now include about half the regions with a low density of FDI employment (48,82 percent). Furthermore, EU regions from these "lagging behind" income classes reflect high stationary probabilities (about 95 percent) and face lower transition probabilities (5,88 percent) of ascending into income classes 3 or 4.

Estimation results for sample of CEEC

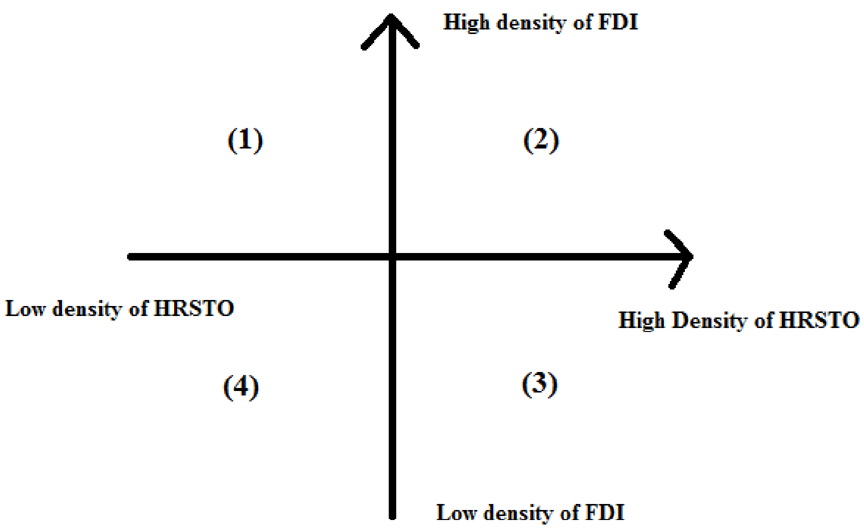
For the sub-sample of regions in CEECs (see Annex Table 4b), we find similar results by considering the FDI stock density in terms of foreign generated turnover, as mentioned for the EU26 sample. The initial and the limiting distributions also reveal that regions with above average FDI stocks are richer from the beginning of the observation period, and also tend to be richer in the long run than regions in the sub-sample with below average FDI stocks. In contrast to the findings for the EU26, CEEC regions with a higher FDI density face a higher probability of moving upwards into income classes 4 and 5 (46 percent) than of moving downwards into lower income classes 1 and 2 (38 percent). CEEC regions with a below median FDI density face an equal probability of moving upwards or downwards and also face higher stationary probabilities of remaining in their income class. Thus, the estimation results based on turnover as a measure of FDI stocks indicate a weak positive association between FDI density and growth rates for regions within CEECs.

By comparing these findings with the estimated distributions in the sub-sample of CEEC regions with a below median density of FDI employment (see Annex Table A5b), the results show a similar picture of "lagging behind" regions that face only low growth probabilities of entering the middle income class. Surprisingly, and in contrast to the findings for the EU26 sample, the sub-sample of CEEC regions with an above average density of FDI employment seems also to favor only certain regions in the income distribution. The limiting distribution shows that the middle income class 3 shrank (up to 10 percent), while the income classes 2 and 4 increased. Furthermore, neither of the PCPI classes 1 and 2 in this sub-sample face any growth prospects of ascending to higher PCPI classes.

4.3 Accounting for FDI stocks and human capital

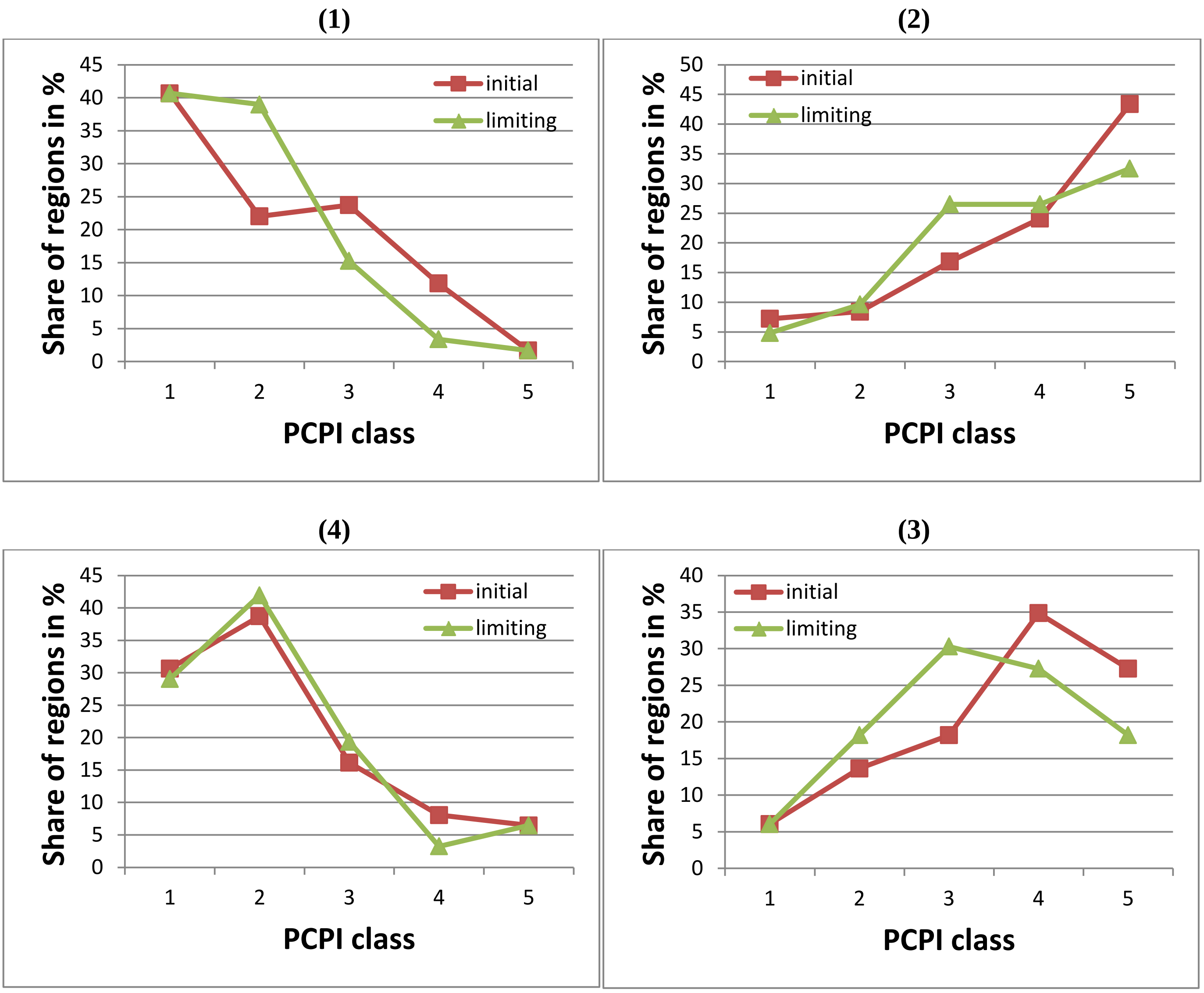
In order to test the relationship between FDI stocks, human capital endowment and changes to the regional income distribution, we classify four groups of regions based on a taxonomy along two dimensions: FDI stocks (FDI) measured in terms of foreign employees, and human capital endowment measured in terms of human resources in science and technology occupations (HRSTO). The differentiation into above and below average groups is based on the median for each dimension at the start of our observation period (2003).

Figure 4: Stylized taxonomy of regions in terms of FDI and HRSTO densities



According to the above stylized taxonomy, group (1) is composed of regions that are characterized by high FDI stocks and low HRSTO endowment. In this group, development is potentially FDI-led, largely uncoupled from existing human capital endowment within these regions. Group (2) contains regions that show high endowment of FDI stocks as well as HRSTO. Group (3) covers regions that show high initial levels of HRSTO endowment with below average FDI stocks. This group could constitute the type of region that potentially follows a domestic-led development path, since the technology related human capital is relatively high and largely linked to domestic capital. Group (4) combines regions with relatively poor starting conditions, i.e. below average FDI stocks as well as below average HRSTO endowment. Figure 5a illustrates the initial and limiting distributions of the estimated Markov transition matrices for all European regions in the above described groups of regions and the corresponding income classes.

Figure 5a: Income distribution across EU regions, 2003–2010, by FDI and HRSTO densities – initial and limiting distributions



Source: Own estimations from the sample data

The limiting distributions for the four sub-samples in graphs (1) to (4) indicate that the FDI-led increases in long-term growth rates in European regions are conditional on a high accumulation of HRSTO. Graphs (2) and (3) show a positive association between income growth and higher human capital endowment. EU regions with a high share of HRSTO face particularly higher probabilities of being in one of the two above-median income classes than EU regions with a low density of HRSTO (graphs (1) and (4)). This implies that the domestic and FDI led regional growth path is driven mainly by human capital-related technological accumulation. In addition, the comparison of the limiting distributions in Figure 5a shows that regions with higher FDI stocks have only slightly higher probabilities of reaching higher income classes.

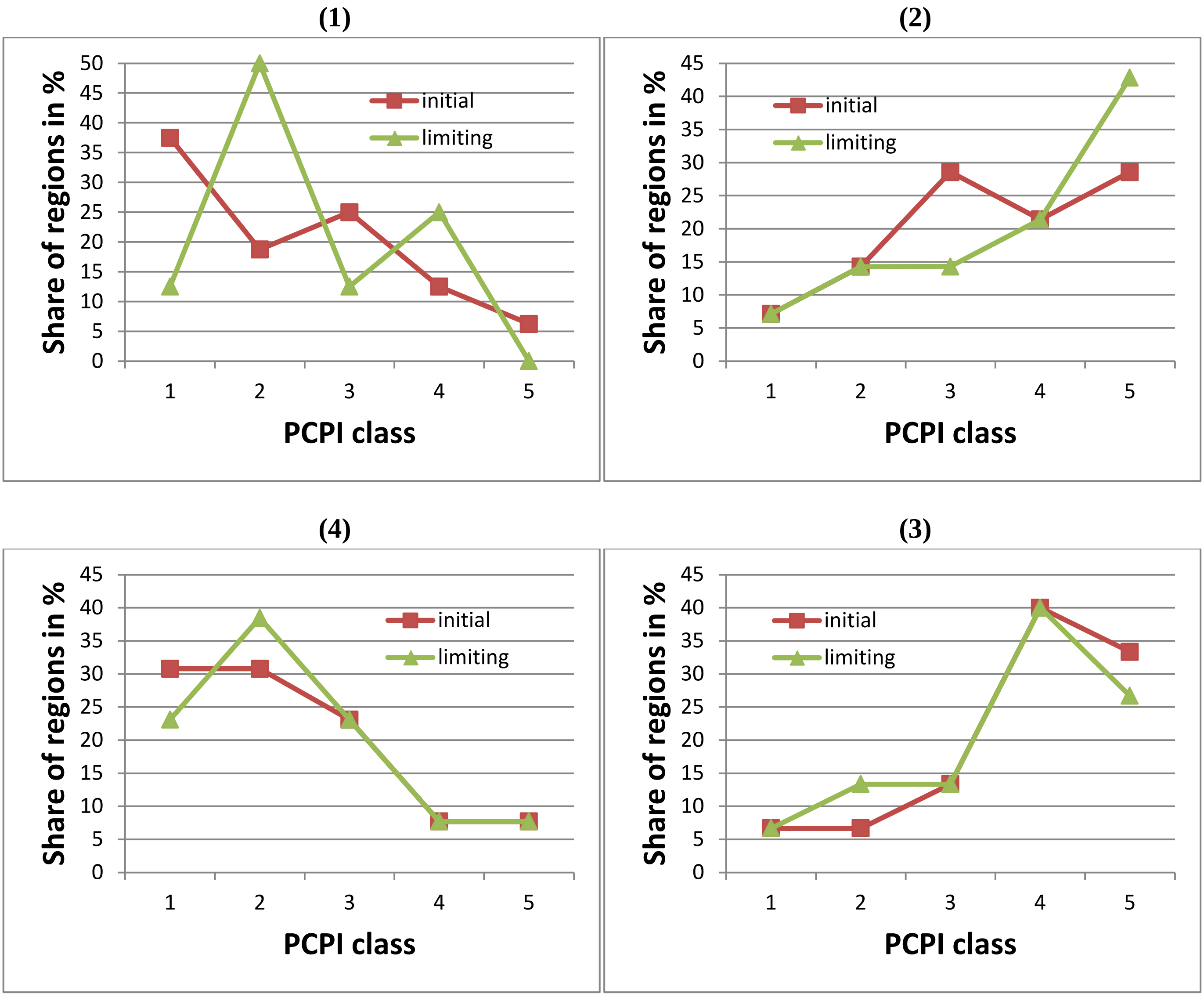
The comparison of initial and limiting distributions provides additional insights into the dynamics of the income distribution: Firstly, EU-regions with a high FDI stock coupled with a high density of HRSTO (graph (2)) have much higher long-term income growth rates (60 % for the PCPI classes 4 and 5) than all the other groups of regions. Secondly, while graphs (1) and (4) show no evidence of the process of convergence within their taxonomy groups, the distribution of regions from taxonomy groups (2) and (3) with a high HRSTO accumulation are homogenous with the income convergence detected above.

Now we turn to the integrated analysis of the relationship between FDI, human capital and growth dynamics for the sub-sample of CEEC regions in the EU. In order to do this we classify the sub-sample of CEEC regions into the four groups of regions based in their endowment with FDI and HRSTO at the start of our observation period (2003). The graphs (1) to (4) depict the initial and limiting distributions for the four corresponding groups of CEEC regions (see Figure 5b).

As in the results for all European regions, we find that regions in CEEC characterized by high FDI stocks as well as high HRSTO endowment are more likely to experience catch-up growth. The limiting distributions of graphs (2) and (3) indicate a positive relationship between long-term growth and higher stocks of HRSTO, regardless of the FDI density within the region. As a result, the group of regions where a high share of HRSTO is complemented by high initial FDI stocks shows considerably higher probabilities (about 65% in graphs (2) and (3)) of remaining in the high income classes.

In contrast to the above findings for all EU regions, the comparison of initial and limiting distributions shows that CEEC regions with a high degree of HRSTO endowment (graphs (2) and (3)) have strengthened their leading positions in income distribution instead of falling back.

Figure 5b: Income distribution across CEEC regions, 2003–2010, by FDI and HRSTO densities – initial and limiting distributions



Source: Own estimations from the sample data

If we take a look at the types of CEEC regions that have considerably higher growth prospects initiated by higher HRSTO endowment, we find that all capital regions of CEECs are on this list (see Annex Table A7). Added to this, while the distribution of CEEC regions with high densities of human capital reflects much higher income growth prospects, the opposite distribution can be seen in graphs (1) and (4). These results confirm the overall process of divergence for all CEEC regions found in the income distribution, and validate the high persistence for both ends of the income distribution.

5. Discussion

5.1 Weak convergence across the EU and a poverty trap in CEECs

Earlier studies examining the EU-15 regional income growth dynamics between 1980 and 1995 produced different results. Investigations based on a Markov chain approach found that the regional income distribution is converging towards a tighter distribution (Quah, 1996b) with high persistence in income classes (see also Carrington, 2006). The majority of studies have found evidence of convergence towards the middle income class of European regions (Magrini, 1999; Castro, 2003), while some investigations also exhibits a "poverty trap" (see also Neven, 1995; Le Gallo, 2004) and a "lack of convergence (…) from the group of the poorest regions" (Lòpez-Bazo et al. 1999, p.357). Our results indicate that regional disparities in per capita income between regions of 24 EU countries decreased over the period 2003-2010. This finding is in line with existing studies that identified low income convergence processes for Europe at the national and sub-national level of analysis (Cappelen et al. 2003; Geppert and Stephan, 2008).

Prior studies found a rise in regional income inequality in the CEEC from the early stages of transition (Brzeski and Colombatto, 1999; Römisch, 2003), that continued throughout the accession period or even intensified (Petrakos et al., 2005; Ezcurra et al, 2007; Kallioras and Petrakos, 2010). Our evidence from the evolution of the income distribution across CEECs reveal increasing regional disparities in GDP per capita income, since the lowest income classes have only low probabilities of catching up with the middle income class. Furthermore, we find evidence for a concentration of certain regions in income classes at both ends of the income distribution. In particular, the rapid GDP per capita growth for capital regions widens the regional income disparities in CEECs (Darvas, 2014). This finding would support the hypothesis of a "poverty-trap" for lagging regions within CEECs (LeGallo, 2004).

5.2 FDI and human capital as determinants of income convergence

Our analysis shows only limited evidence that high FDI stocks per se are related with greater chances of long term catching-up. Although, EU regions with high FDI density are more likely to have more favorable growth prospects than EU regions with low FDI density, they have been falling back in the income distribution over time and converged slowly with the middle income class. This result does not fully support hypothesis 1a, that postulated a positive relationship between FDI stock and upward mobility in the income distribution.

Furthermore, we find no indications in favor of the hypothesis 1b, that expected agglomeration of FDI within regions to be positively associated with catching-up of regions at the lower end of the income distribution. The result for EU regions seems to differ from findings for the US. Bode and Nunnekamp (2010) showed that US states with a high FDI density have a greater chance of being “rich” in the long run, while “poorer” states will remain so and diverge from the national per capita income average.

The key contribution of our research relates to the role of human capital in the convergence process across European regions. In particular, we find that human capital is associated with higher income catch-up probabilities disregarding the given level of FDI stocks. Since we measure human capital in terms of human resources in science and technology, our findings are in line with of Mulas-Granados and Sanz (2008) who found that changes in technology endowment are an important driver of changes in the distribution of per capita income across EU regions over time. Whereas, Pablo-Romero and Gomez-Calero (2013) emphasize that the effect of human capital on economic growth depends significantly on the increments in private physical capital (at the example of Spanish provinces); we can show evidence for a positive interaction between human capital and *foreign* physical capital in their relationship income convergence. This finding is in line with our hypothesis 2.

Our study carries implications that extend the work by Borensztein et al (1998). This seminal paper identified that the effect of FDI on economic growth is conditional upon the level of human capital in the host economy. Their investigation refers to a set of developing countries and was implemented at the national a level of analysis. We can show that their finding holds also at the regional level and in the context of developed economies. In line, with their study we find a positive interaction between foreign physical capital and human capital. Yet, our research seems to suggest that regional catch-up seems to necessitate primarily human capital related *technological* endowment disregarding the given stock of foreign physical capital. This result applies to regions in the advanced as well as emerging European economies.

Thus, despite evidence for positive direct and indirect effects of FDI in European emerging markets (Hanousek et al., 2011); FDI per se is not the solution to tackle economic backwardness. This has also been demonstrated for other non-European emerging and developing markets (see for example Herzer et al., 2008; Yalta, 2013). So why does FDI fail to promote convergence in lagging regions? A possible explanation is provided by Girma and Wakelin (2001). They suggest that localized FDI-related spillovers benefit those regions that are able to absorb the knowledge spillover. If host regions do not possess the capacity to absorb the knowledge and the technology incorporated, FDI carries a risk of crowding-out for domestic investments and harm the regional economic performance.

The question why FDI fails to tackle underdevelopment of regions (and countries) deserves further attention, given the general importance dedicated to FDI in economic development. A possible area of future investigation relates to the analyses whether the detected complementary between FDI and human capital holds when taking into account industry or sector-specific circumstances. The relationship between FDI and human capital might change when accounting for regions with capital cities vs. regions at the periphery. Taking growing regional income disparities into the focus, future research might investigate potential barriers and facilitators for spillover effects from FDI and agglomeration effects between regions (in particular from regions with capital cities to other regions).

5.3 Policy implications for Europe and CEECs

CEECs adopted a unique growth model combining institutional anchoring to the EU, integration of product markets through trade in goods and services, capital mobility including through large-scale FDI inflows, and eventually labor mobility (Becker et al. 2010). Over time CEECs converged at the country level but with simultaneously increasing sub-national disparities driven primarily by the rapid growth of capital cities. From a regional policy point of view, it has been suggested to enlarge development areas beyond the small group of core areas, towards second (and third)-rank cities (Gorzelak, 2015). This strategy reduces inflationary pressures, enlarges the economic base of countries. The second-order cities should develop their metropolitan functions, thus supplementing the capital cities. Such a territorial pattern could slow down the growth of regional disparities and would allow for better accessibility of high-order services (ibid).

Our results show that human capital related technological endowment is a decisive factor contributing to regional income convergence. Thus EU cohesion policy that improves the conditions for investments in peripheral regions through funding of training, infrastructure and R&D (EC, 2007) is highly relevant. However, it has also been highlighted that R&D and innovation policies will be a factor of further divergence across the EU, since they reinforce existing agglomerations and growth poles (Gorzelak, 2015). Furthermore, it has been postulated that innovation policies need to reflect country and region specific conditions in CEECs rather than ‘best practice’ from advanced EU15 countries (Havas et al 2015). This has also implication for the role of FDI in the catch-up process. Our results indicate that FDI own is not able to sustain a catch-up process. It must be complemented by human capital and technological development to harness its full growth potential. Therefore, enhancing domestic technological capabilities as well as aligning domestic and foreign networks should be a priority in the regeneration of regional systems of innovation (Tunzelmann et al. 2010).

6. Conclusion

This paper has investigated the evolution of GDP per capita income disparities in the European regions, and separately for the CEEC regions, over the period from 2003 to 2010. The study applied an infinite first-order Markov chain approach to a sample of 269 European regions. The evidence indicates a weak process of overall income convergence among all EU regions investigated during the observation period. For CEEC regions, we find support for a "poverty trap" of poor regions in lower income classes. Given that especially the capital regions of the CEECs enjoyed high per capita growth rates, positive spillover effects from FDI contributing to catch-up and regional convergence are strongly localized.

In terms of determinants of income convergence, this paper shows that FDI on its own is not able to sustain regional convergence within the EU or CEECs. Instead, we find that catch-up is driven by human capital-related technological endowment. The positive effect of FDI is conditional upon the level of human capital within regions. In order to attain upward mobility of lagging regions, we conclude that regional policy should focus on the territorial development of second-rank cities. R&D and innovation policies should not mimic 'best-practice' of EU15 countries, but instead focus on the development of domestic technological capabilities and the alignment of FDI into this process.

Annex

Table A3: Total number of foreign owned firms (2003-2010)

Country	**Total number of firms with foreign ownership**	
EU-15	**2003**	**2010**
Austria	1.863	2.603
Belgium	2.080	3.359
Denmark	736	1.740
Finland	388	1.037
France	7.669	10.260
Germany	10.532	9.875
Greece	801	1.112
Ireland	183	1.091
Italy	1.944	3.943
Luxembourg	46	89
Netherlands	1.776	3.803
Portugal	161	1.427
Spain	6.156	6.788
Sweden	843	2.656
United Kingdom	12.765	14.558
EU-15 total	**47.943**	**64.341**
CEEC		
Bulgaria	1.167	2.090
Croatia	264	1.261
Czech Republic	595	2.370
Estonia	145	1.250
Hungary	290	716
Latvia	256	847
Lithuania	84	836
Poland	1.443	6.097
Romania	6.240	8.992
Slovakia	16	1.215
Slovenia	2	511
CEEC total	**10.502**	**26.185**

Table A4a: Income distribution across EU regions (levels of growth), 2003–2010, by the density of foreign turnover

Share of foreign turnover > median of foreign turnover							
	initial distribution		final distribution				
	N	%	1	2	3	4	5
1	29	20,57	93,10	6,90	0,00	0,00	0,00
2	22	14,89	4,76	80,95	9,52	4,76	0,00
3	29	20,57	0,00	37,93	51,72	10,34	0,00
4	28	19,86	0,00	3,57	39,29	42,86	14,29
5	34	24,11	0,00	0,00	0,00	20,59	79,41
limiting	142	100	19,86	21,99	19,86	16,31	21,99
Share of foreign turnover < median of foreign turnover							
	initial distribution		final distribution				
	N	%	1	2	3	4	5
1	24	18,90	95,83	4,17	0,00	0,00	0,00
2	33	25,98	0,00	93,94	3,03	3,03	0,00
3	22	17,32	0,00	18,18	72,73	9,09	0,00
4	28	22,05	0,00	0,00	32,14	67,86	0,00
5	20	15,75	0,00	0,00	0,00	10,00	90,00
limiting	127	100	18,11	28,35	20,47	18,90	12,50

Source: Own estimations from the sample data

Table A4b: Income distribution across CEEC regions (levels of growth), 2003–2010, by the density of foreign turnover

Share of foreign turnover > median of foreign turnover							
	initial distribution		final distribution				
	N	%	1	2	3	4	5
1	6	21,43	50,00	50,00	0,00	0,00	0,00
2	4	14,29	0,00	100	0,00	0,00	0,00
3	5	17,86	0,00	20,00	60,00	0,00	20,00
4	5	17,86	0,00	0,00	20,00	60,00	20,00
5	8	28,57	0,00	0,00	0,00	37,50	62,50
limiting	28	100	10,71	28,57	14,29	21,43	25,00
Share of foreign turnover < median of foreign turnover							
	initial distribution		final distribution				
	N	%	1	2	3	4	5
1	5	17,86	80,00	20,00	0,00	0,00	0,00
2	5	17,86	0,00	60,00	40,00	0,00	0,00
3	7	25,00	0,00	14,29	57,14	28,57	0,00
4	6	21,43	0,00	33,33	0,00	66,67	0,00
5	5	17,86	0,00	0,00	0,00	20,00	80,00
limiting	28	100	14,29	25,00	21,43	25,00	14,29

Source: Own estimations from the sample data

Table A5a: Income distribution across EU regions (levels of growth), 2003–2010, by the density of foreign employees

Share of foreign employees > median of foreign employees							
	initial distribution		final distribution				
	N	%	1	2	3	4	5
1	29	20,57	93,10	6,90	0,00	0,00	0,00
2	20	14,18	5,00	80,00	10,00	5,00	0,00
3	26	18,44	0,00	34,62	57,69	7,69	0,00
4	29	20,57	0,00	3,45	37,93	44,83	13,79
5	37	26,24	0,00	0,00	0,00	18,92	81,08
limiting	142	100	19,86	19,86	19,86	16,31	24,11
Share of foreign employees < median of foreign employees							
PCPI class	initial distribution		final distribution				
	N	%	1	2	3	4	5
1	24	18,90	95,38	4,17	0,00	0,00	0,00
2	34	26,77	0,00	94,12	2,94	2,94	0,00
3	25	19,69	0,00	24,00	64,00	12,00	0,00
4	27	21,26	0,00	0,00	33,33	66,67	0,00
5	17	13,39	0,00	0,00	0,00	11,76	88,24
limiting	127	100	18,11	30,71	20,47	18,90	11,81

Source: Own estimations from the sample data

Table A5b: Income distribution across CEEC regions (levels of growth), 2003–2010, by the density of foreign employees

Share of foreign employees > median of foreign employees							
	initial distribution		final distribution				
	N	%	1	2	3	4	5
1	6	21,43	33,33	66,67	0,00	0,00	0,00
2	4	14,29	0,00	100	0,00	0,00	0,00
3	8	28,57	0,00	12,50	62,50	12,50	12,50
4	4	14,29	0,00	0,00	0,00	75,00	25,00
5	6	21,43	0,00	0,00	0,00	33,33	66,67
limiting	28	100	7,14	32,14	17,86	21,43	21,43
Share of foreign employees < median of foreign employees							
PCPI class	initial distribution		final distribution				
	N	%	1	2	3	4	5
1	5	17,86	100	0,00	0,00	0,00	0,00
2	5	17,86	0,00	60,00	40,00	0,00	0,00
3	4	14,29	0,00	25,00	50,00	25,00	0,00
4	7	25,00	0,00	28,57	14,29	57,14	0,00
5	7	25,00	0,00	0,00	0,00	28,57	71,43
limiting	28	100	17,86	21,43	17,86	25,00	17,86

Source: Own estimations from the sample data

Table A6a: List of EU regions by the difference in growth levels

NUTS2 Code	Name of region	Level of growth	
		+1	**+2**
AT-13*	Wien	1	0
BE-31	Wallonisch-Brabant	1	0
BE-35	Provinz Namur	1	0
CZ-01*	Praha	0	1
DE-30*	Berlin	1	0
DE-94	Weser-Ems	1	0
DE-A3	Münster	1	0
ES-21	País Vasco	1	0
GR-30*	Athens	1	0
GR-42	Südliche Ägäis	1	0
NL-32*	Noord-Holland	1	0
NL-42	Limburg	1	0
PL-12*	Mazowieckie	1	0
RO-32*	București-Ilfov	0	1
SE-12	Östra Mellansverige	1	0
SI-02*	Zahodna Slovenija	1	0
SK-01*	Bratislavský kraj	0	1

Note: *Capital regions

Table A6b: List of CEEC regions by the difference in growth levels

NUTS2 Code	Name of region	Level of growth	
		+1	+2
BG-41	Yugozapaden	0	1
CZ-04	Severozápad	1	0
CZ-05	Severovýchod	1	0
CZ-06	Jihovýchod	1	0
CZ-07	Střední Morava	1	0
CZ-08	Moravskoslezsko	1	0
LT-00	Lithuania	1	0
LV-00	Latvia	0	1
PL-11	Łódzkie	1	0
PL-21	Małopolskie	1	0
PL-33	Świętokrzyskie	1	0
PL-34	Podlaskie	1	0
PL-42	Zachodniopomorskie	1	0
PL-43	Lubuskie	0	1
PL-51	Dolnośląskie	1	0
PL-52	Opolskie	1	0
PL-62	Warmińsko-Mazurskie	1	0
PL-63	Pomorskie	1	0
RO-11	Nord-Vest	1	0
RO-12	Centru	1	0
RO-22	Sud-Est	1	0
RO-31	Sud-Muntenia	1	0
RO-32	București-Ilfov	0	1
RO-41	Sud-Vest Oltenia	1	0
RO-42	Vest	1	0
SK-02	Western Slovakia	0	1
SK-03	Central Slovakia	1	0
SK-04	Eastern Slovakia	0	1

Table A7: List of CEEC regions – Integrated Analysis

High density of FDI & high share of HRSTO	
NUTS2 Code	**Name of region**
CZ-01*	Praha
CZ-02	Střední Čechy
CZ-06	Jihovýchod
CZ-08	Moravskoslezsko
EE-00*	Estonia
HR-04*	Continental Croatia
LT-00*	Lithuania
LV-00*	Latvia
PL-12*	Mazowieckie
PL-42	Zachodniopomorskie
PL-62	Warmińsko-Mazurskie
RO-32*	București-Ilfov
Low density of FDI & high share of HRSTO	
BG-31	Severozapaden
BG-41	Yugozapaden
CZ-03	Southwest
CZ-04	Northwest
CZ-05	Northeast
CZ-07	Central Moravia
HR-03	Adriatic Croatia
HU-10*	Central Hungary
HU-21	Central Transdanubia
HU-23	Southern Transdanubia
HU-32	Northern Great Plain
PL-22	Śląskie
SI-01	Eastern Slovenia
SI-02*	Western Slovenia
SK-01*	Bratislava Region
SK-02	Western Slovakia
SK-03	Central Slovakia

Note: *Capital regions

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