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Income convergence prospects in Europe: Assessing the role of human capital dynamics

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Abstract

We employ income projection models based on human capital dynamics in order to assess quantitatively the role that educational improvements are expected to play as a driver of future income convergence in Europe. We concentrate on income convergence dynamics between emerging economies in Central and Eastern Europe and Western European countries during the next 50 years. Our results indicate that improvements in human capital contribute significantly to the income convergence potential of European emerging economies. Using realistic scenarios, we quantify the effect that future human capital investments paths are expected to have in terms of speeding up the income convergence process in the region. The income projection exercise shows that the returns to investing in education in terms of income convergence in Europe could be sizeable, although it may take relatively long for the poorer economies of the region to rip the growth benefits.

JEL codes: O47, O52, I25, P27.
Keywords: Economic growth, income convergence, human capital, income projections, Europe, emerging economies.

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1 Introduction

The heterogeneity across countries in the European Union (EU) has increased significantly after the last rounds of enlargements. Differences in living standard across the countries that currently compose the EU are considerably large and the income growth experience over the last decades also differs strongly. In 1995, average GDP per capita in Romania (the country with the lowest income per capita in the EU) was only 20% of that in the Netherlands. Until 2009, the differences in per capita income between the richest and the poorest countries of the EU decreased, but they are still remarkably large. After adjusting for purchasing power, GDP per capita in 2009 was four times higher in Netherlands with respect to Romania.

The recent global financial crisis has had a sizeable and asymmetric effect on income per capita growth the EU and in particular in Central and Eastern Europe (CEE). While the Baltic countries experienced average GDP growth rates of around -15.5% in 2009, Poland had a growth rate of GDP of 1.8%. Such developments have contributed to creating a discussion both at the academic level and in policy-making circles about the potential danger of income divergence in Europe. The results of Archibugi and Filippetti (2011) indicate that the crisis has affected innovation capabilities, one of the engines of economic growth, in European economies and in particular in Eastern Europe. Such developments take place after income convergence between emerging economies in Eastern Europe and the rest of the EU has been the rule in the last decades. Against this background, the question of whether further income convergence is a likely scenario in the future and which policies are efficient at fostering growth in emerging Europe are in the center of the policy discussion at the moment.

In this paper we contribute to the discussion of the long-run economic growth prospects of Eastern Europe using scenario-based income projection models. We concentrate on building income per capita scenarios for European countries based on an estimated econometric model with a detailed human capital component. Using new projections of population by educational attainment and simple scenarios for the development of physical capital investment and total factor productivity growth, we construct distributions of income per capita in EU countries up to the year 2070. We pay particular attention to assessing quantitatively the role played by human capital developments as a determinant of income convergence dynamics in Europe in the future. The importance of such human capital as a driver of economic growth and convergence in the region has been recently emphasized by, for instance, Kutan and Yigit (2009). We use econometric models that explicitly account for the effects of education as a catalyst of innovation and technology adoption in the spirit of Benhabib and Spiegel (1994).

Improvements in educational investments speed up the path towards full convergence with the rest of the EU for the whole group of Eastern European economies, but the timing of ripping such benefits differs among countries of the region. Our results indicate that the richer economies in Eastern Europe can obtain important benefits from improving their educational attainment levels in terms of accelerating their income convergence process with respect to the rest of the EU. Furthermore, these convergence benefits would realize in the forthcoming decades, while the horizon for such effects in poorer economies of Eastern Europe is significantly longer.

In spite of the obvious importance of the question tackled in our paper, few other studies assess quantitatively the convergence prospects of the CEE region using income projection methods. Our analysis is related to the contribution by Hlouskova and Wagner (2005), who present income projections for economies in CEE but do not concentrate explicitly on the role of human capital dynamics as a determinant of income growth in the region, as we do here. As in Hlouskova and Wagner (2005), we also put particular effort in quantitatively assessing the uncertainty surrounding income predictions and convergence paths. In this vein, we construct our conclusions based on the distribution of future income levels implied by our projection models, thus taking a probabilistic approach to the issue of future economic growth instead of concentrating on average, median or modal values in such distributions. Other studies take this arguably simpler approach, offering only point estimates of projected economic growth or time to convergence (see for example European Economic Advisory Group (2004)).

The study is organized as follows. Section 2 summarizes the income convergence experience in Europe over the last fifteen years. Section 3 presents the econometric model which is estimated and used to calculate income projection scenarios for EU countries. Section 4 sets up the design of the projections and investigates the effect of human capital investments as a factor affecting income convergence in the next decades. Section 5 concludes.

2 Income convergence in Europe: The recent experience

In this section we assess the recent experience of income convergence between emerging markets in Central and Eastern Europe and the rest of the European Union. We consider the 27 members of the European Union as of 2012 plus Croatia, which will become part of the EU on 1 July 2013. Our interest is to evaluate the income convergence process that has taken place since 1995 in Europe, concentrating in the relative income dynamics of the group of Central and Eastern European emerging economies (EM-11, formed by Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Slovak Republic and Slovenia) with respect to the rest of the European Union, which we denote EU-17.

Table 1 presents the average growth rates of GDP per capita for the two regions during the period 1995-2009. Average economic growth in the period 1995-2009 was around three times higher in EM-11 than in EU-17, which resulted in the average income gap between EU-17 and EM-11 closing from 65% to 51%. The 1995-2000 period was marked by relatively slow convergence speed, with EM-11 growing at a yearly rate which was roughly 1 percentage point higher than EU-17. The difference in average economic growth rates between the two regions speeded up at the beginning of the new millennium. During the 2005-2009 period, which covers the recent economic crisis, the convergence process proceeded rapidly due to the fact that on average income growth rates were less affected by the global recession in the EM-11 region than in EU-17.

Table 1: Income growth 1995-2009, EU-17 and EM-11

	1995-2000	2000-2005	2005-2009	1995-2009
Yearly GDP per capita growth, EU-17	2.53%	1.26%	-0.07%	1.33%
Yearly GDP per capita growth, EM-11	3.51%	4.64%	3.43%	3.89%

The scope of the overall convergence process between EU-17 and EM-11 hides sizeable differences among countries within the EM-11 region. While Baltic countries had an average yearly GDP per capita growth rate around 5% during the 14 years that allowed them to roughly double their GDP per capita, the Czech Republic or Hungary grew at a yearly rate of 3%, a speed that implies that it would take them 24 years to double their income per capita level.

Differences in economic growth rates within EU-17 were also stark, ranging form 0,31% per year in Italy to 3,39% in Ireland.

In the spirit of β-convergence analysis (see Barro and Sala-i-Martin (1992)), Figure 2 presents a scatterplot of the income per capita in 1995 against the average income growth between 1995 and 2009. The negative relationship between the two variables indicates that (unconditional) income convergence took place in this period, with relatively poorer countries in Europe growing at a significantly higher speed than their richer counterparts. The overall income convergence pattern within and across regions has changed considerable in the period under analysis. Table 2 shows the estimates of β convergence regressions of the type

$$\frac{1}{\tau}\Delta \log y_i = \beta_0 + \beta_1 \log y_{0i} + u_i, \quad (1)$$

where y_{0i} refers to income per capita evaluated in the first year of the period considered and $\frac{1}{\tau}\Delta \log y_i$ is the average income per capita growth over the period, assumed of length τ years. We estimate regressions such as (1) for the subperiods 1995-2000, 2000-2005 and 2000-2009. The estimates of β_1 for these subperiods are shown in Table 1, together with the parameter estimate corresponding to the full sample. The estimates indicate that the last 15 years income per capita in Europe tended to aignificantly equalize across economies. In particular, the convergence between the groups of Western and Eastern European countries have driven this process and the speed of income convergence was highest in the period 2000-2005. The evidence for income convergence within the two groups of economies (EM-11 and EU-17) is very limited, with only convincing evidence of unconditional β-convergence within EM-11 countries in the period 2000-2005.

The results sketched hitherto are fully in line with the existing literature on the income convergence process within Europe over the last two decades. Rapacki and Próchniak (2009), for instance, confirm the existence of β-convergence in income for CEE economies during the period 1990–2005, albeit at different speed in different subperiods, with statistically significant convergence only in 2000–2005 for CEE countries. Similar results are found in Vojinović et al. (2010) or Matkowski and Próchniak (2007).

3 An income projection model for Europe

3.1 The theoretical setting

We use a simple estimated income projection model to assess income convergence scenarios for Europe. The projection model is based on a standard aggregate production function with heterogeneous labour input. We differentiate labour input by educational attainment level,

$$Y_t = A_t K_t^{\alpha} \prod_{j=0}^{3} L_{j,t}^{\beta_j}, \quad (2)$$

where Y_t is total output, A_t stands for total factor productivity, K_t denotes the total capital stock and L_j corresponds to the working age population with educational attainment j, with j taking values $j = 0$ (no education), $j = 1$ (some primary education), $j = 2$ (at least junior secondary school attainment) and $j = 3$ (some tertiary education level attained).

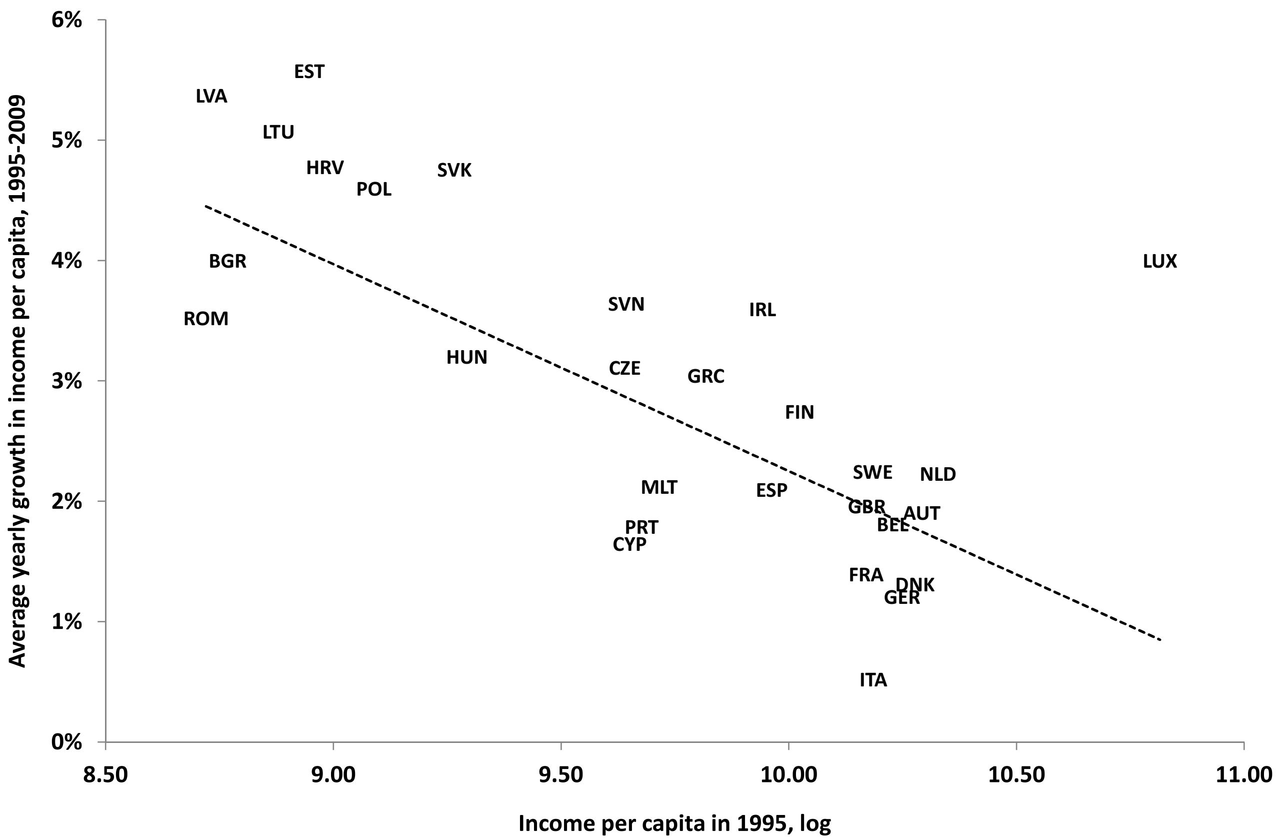

Figure 1: Average yearly income growth versus initial income in EU-28, 1995-2009

Table 2: Unconditional β-convergence regressions, 1995-2009

	EM-11	EU-17	EU-28
Period 1995-2000			
Initial income (1995)	0.0070	-0.0039	-0.0019
	[0.0208]	[0.0128]	[0.0057]
Observations	11	17	28
R^2	0.012	0.006	0.004
Period 2000-2005			
Initial income (2000)	-0.0360**	0.0057	-0.0350***
	[0.0138]	[0.0090]	[0.0052]
Observations	11	17	28
R^2	0.429	0.026	0.631
Period 2005-2009			
Initial income (2005)	-0.0211	0.0170	-0.0155**
	[0.0194]	[0.0116]	[0.0070]
Observations	11	17	28
R^2	0.0194	0.0116	0.0070
Full period 1995-2009			
Initial income (1995)	-0.0138*	0.0047	-0.0172***
	[0.0074]	[0.0076]	[0.0032]
Observations	11	17	28
R^2	0.282	0.025	0.520

Notes: The dependent variable is the growth rate of GDP per capita over the corresponding period. Standard errors in brackets. *(*)[***] stands for significance at the 10%(5%)[1%] level.

Rewriting (2) in growth rates implies that the growth rate of total output depends linearly on the growth rate of each one of the factors of production (total factor productivity, the capital stock and each one of the populations groups by education level),

$$\Delta \log Y_t = \Delta \log A_t + \alpha \Delta \log K_t + \sum_{j=0}^{3} \beta_j \Delta \log L_{j,t}. \tag{3}$$

Such a specification assumes that the mechanism linking human capital to economic growth is exclusively related to labour productivity improvements taking place through education. This implies that it is the accumulation of human capital (that is, the growth rate of labour input with higher educational attainment level) which is related to improvements in growth rates of total output and thus level effects in income per capita (see Mankiw et al. (1992) for a seminal exogenous growth model with such a theoretical framework). In the spirit of the Nelson-Phelps paradigm (see Nelson and Phelps (1966), Benhabib and Spiegel (1994) and Lutz et al. (2008)), we assume that the role of education as an engine of economic growth goes beyond labour productivity improvements and that the stock of human capital also plays the role of a catalyst of technology improvements through its effect on innovation and technology adoption. In consequence, we follow Benhabib and Spiegel (1994) and assume that the growth rate of total factor productivity depends on (a) the distance to the technology frontier, as approximated by the income per capita level of the respective country, (b) the proportion of the workforce with tertiary education, which is used to proxy for the technology innovation potential of the economy and (c) the interaction between the level of income per capita (i.e., the distance to the technology frontier, and the share of working age population with tertiary education, which accounts for technology adoption as a driver of income convergence.

Such a theoretical setting implies that education plays the role of, on the one hand, directly increasing labour productivity through acquired skills and on the other hand of enabling the creation and adoption of new technologies, thus increasing economic growth by affecting the growth rate of total factor productivity. This leads to a specification where the growth rate of population by educational attainment level as well as its composition in terms of educational characteristics have an effect of economic growth. The model resulting from such a specification is thus given by

$$\Delta \log Y_t = \lambda \log y_t + \theta \frac{L_{3,t}}{\sum_{j=0}^{3} L_{j,t}} + \phi \frac{L_{3,t}}{\sum_{j=0}^{3} L_{j,t}} \log y_t + \alpha \Delta \log K_t + \sum_{j=0}^{3} \beta_j \Delta \log L_{j,t}, \qquad (4)$$

where y_t stands for income per capita. Specification (4) serves as a base for the econometric model which is estimated and used to obtain income per capita projections for European countries.

3.2 Estimation results and the projection model

The specification given by (4) is estimated using a panel spanning data for 32 European countries (based on the UN definition of world regions) for the period 1970-2010, with growth rates defined over 5-year non-overlapping intervals.[1] Our specification includes fixed country-specific effects as well as fixed time effects, which can be interpreted in the framework of the theoretical setting as overall movements in the technology frontier that are independent of those caused by improvements in human capital.

The data on income per capita and total GDP for the estimation are sourced from the Penn World Table 7.0 (Heston et al. (2011)), physical capital stocks are estimated using the perpetual inventory method based on investment rates from the Penn World Table 7.0 assuming a depreciation rate of 6%. The data on population by educational attainment level are obtained from the IIASA-VID dataset (see Lutz et al. (2007)), which provides data on population by age and educational attainment level for most countries of the world. [2] We evaluate all variables in the initial year of the subperiod which defines the growth rates, so as to partly avoid endogeneity problems in the panel regressions.

[1]The countries in our sample are Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Macedonia, Malta, Netherlands, Norway, Poland, Portugal, Russia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Ukraine and United Kingdom.

[2]The human capital data are available from `http://www.iiasa.ac.at/Research/POP/edu07/index.html?sb=12`.

Table 3: Panel estimates

	(1)	(2)	(3)	(4)
$\Delta \log K_t$	0.765***	0.794***	0.907***	0.960***
	[0.174]	[0.175]	[0.166]	[0.202]
$\Delta \log L_{0,t}$	-0.102	-0.0557	-0.068	
	[0.0915]	[0.0342]	[0.0425]	
$\Delta \log L_{1,t}$	0.118	0.134	0.128*	
	[0.0754]	[0.0885]	[0.0750]	
$\Delta \log L_{2,t}$	1.100*	0.952*	1.328*	1.343**
	[0.578]	[0.510]	[0.526]	[0.552]
$\Delta \log L_{3,t}$	0.132	0.346*	0.205	
	[0.194]	[0.193]	[0.187]	
$\log y_t$		-0.0996***	-0.0679***	-0.0683***
		[0.0158]	[0.0157]	[0.0151]
$L_{3,t}/\sum_{j=0}^{3} L_{j,t}$			4.307***	4.359***
			[1.491]	[1.574]
$(L_{3,t}/\sum_{j=0}^{3} L_{j,t}) \log y_t$			-0.397***	-0.405***
			[0.136]	[0.143]
Observations	203	203	203	203
R^2	0.528	0.658	0.701	0.679
Number of countries	32	32	32	32

Notes: The dependent variable is the growth rate of GDP over the corresponding 5-year period. Robust standard errors in brackets. *(*)[***] stands for significance at the 10%(5%)[1%] level. Estimates based on a panel dataset spanning data for 32 European countries during the period 1970-2010 at 5-year non-overlapping intervals. Panel regression model including fixed country effects and fixed time effects which are not reported in the table.

Table 3 presents the panel regression estimates for different specifications nested within the model which is given by (4). The first column presents the estimates of the model assuming that human capital accumulation affects economic growth exclusively through labour productivity improvements. Such a model corresponds to specification (4) with the restrictions $\lambda = 0$, $\theta = 0$ and $\phi = 0$ imposed. The fixed effects in the model specification implies that an exogenous, country-specific fixed growth rate of total factor productivity is assumed. In addition to the positive economic growth effect through physical capital accumulation, only the growth rate of population with secondary education appears to be exert a (marginally) significant positive effect on GDP growth in this model. In the model estimated in the second column we expand the basic specification used in the first column by including the initial level of income per capita as an extra covariate in the model. The highly significant negative estimated parameter gives strong evidence of conditional convergence, while the rest of the estimated parameters are not qualitatively affected by the inclusion of this variable in the model. The full model in (4) is estimated in the third column of Table (3). The estimated parameters reveal significant technology adoption and innovation effects of tertiary education. The positive estimate associated to the share of working age population with tertiary education attainment points towards growth effects which are modulated through the size of the human capital stock. In addition, the significant negative parameter attached to the interaction term between this variable and the initial income per capita indicates that relatively poorer countries tend to profit more from the technology effect, thus giving evidence of the role of education in facilitating technology adoption for countries which are further away from the technology frontier. It should be noted that, as the human capital effects in the model are specified in a more complete fashion, the elasticity of income growth to physical capital investment (the estimate of α in our production function) increases, a result which is fully on line with Mankiw et al. (1992).

The fourth column of Table 3 presents the estimates of the model selected through general-to-specific variable reduction based on individual significance tests, starting from the model in column 3. The resulting estimated reduced specification is the model that is used for the income projection exercise in the next section and highlights the importance of physical and human capital investment as drivers of economic growth in our sample of European countries. In particular, the productivity, innovation and technology adoption effects of secondary and tertiary education appear particularly important to understand the economic growth and convergence patterns observed in Europe in the last four decades, a result which is in line with those in, for example, Lutz et al. (2008), which uses the same human capital database but a global sample of countries.

4 Income convergence prospects in Europe: An income projection exercise

4.1 Setting and assumptions

Using the estimated model presented in column 4 of Table 3, we obtain income per capita projections for EU countries (including Croatia) over the period 2010-2070. Our projections are based on different scenarios concerning the overall developments in terms of physical capital accumulation, human capital accumulation and technology improvements beyond those implied by human capital dynamics (which in the model are captured by the fixed time effects). The focus is on convergence between Eastern and Western Europe and in particular between the eleven Central and Eastern European emerging economies which experienced a transition from a centrally-planned economic system (a group that we refer to as *emerging EU-11* or EM-11 and that is composed by Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic and Slovenia) and the rest of the European Union (which we label EU-17 and is composed by the rest of the EU as of 2012).

We design different simple scenarios for each one of the main drivers of economic growth in the model, which are described in detail below. Our results are based on simulations obtained by applying different assumptions concerning the behaviour of these variables in each one of the two regions defined (EM-11 and EU-17). The importance of assessing the uncertainty surrounding future developments in economic growth determinants for income projections, in particular for transition economies in Eastern Europe, has been emphasized in the work of Hlouskova and Wagner (2005).

Physical capital accumulation: We specify three different scenarios for investment in physical capital, which we accordingly label *medium*, *low* and *high*. The scenarios are based on the realized physical capital growth rates in the estimation period, with the medium scenario assuming a yearly growth rate of physical capital equal to the median of the observed values for this variable (2.86%), the low scenario assuming a value corresponding to the 25th percentile of the empirical distribution (1.76%) and the high scenario using the 75th percentile (4.68%).

Human capital accumulation: We specify two scenarios concerning human capital accumulation. The first scenario assumes that the shares of working age population with primary, secondary and tertiary education remain constant over the projection period for each country in our sample. Taking into account the expected demographic developments in Europe in the coming decades, which imply a significant decay of the labour force, such a scenario can be considered slightly pessimistic when it comes to future absolute education expenditure paths. We label this scenario *Constant Attainment* and fix the attainment shares realized in 2010 for the period 2010-2070. The growth rate of population with secondary education, which is also required for the simulations, is accordingly assumed to be equal to the projected growth rate of the working age population, so as to keep the share of individuals with secondary school attainment constant. The second human capital scenario assumes that each country in our sample will expand its share of educated population according to the global trends observed in historical data and is accordingly dubbed the *Global Education Trend* scenario. Such a scenario is proposed by KC et al. (2010), which contains the methodological details for the construction of such population projections. This scenario predicts an increase of the share of working age population with tertiary education in Europe (EU-27 plus Croatia) from roughly 23% in 2010 to approximately 42% in 2070. In EM-11 the corresponding value for 2010 is 20.9%, and the scenario foresees an increase to 39.6% by 2070, while in EU-17 the average in 2010 is 25.1% and is expected to increase to 43.7% by the end of the projection period. Using the methodology in KC et al. (2010), total population projections can be obtained by quantifying the effects of educational improvement on fertility rates and using age/education-specific mortality and migration rates to project population by five-year age group and educational attainment. These population projections are utilized to obtain income per capita projections from our total GDP predictions.

Global shocks in income growth: The estimates of the fixed time-effect parameters in our model implies that there have been significant common shocks to GDP growth which have jointly affected all European countries. Furthermore, such shocks had a positive trend in the estimation period. Such shocks can be interpreted as growth effects through shifts in the technology frontier which are unrelated to human capital dynamics, or as global economic growth effects attained through improved market integration in the past decades. We specify two scenarios concerning the potential future behaviour of such shocks. In the *constant* scenario we freeze the period effects at the level implied by the last period (2005-2010) for the projection horizon. In the *trend* scenario we extrapolate the period effects to the future by assuming that they will grow at the average rate observed in the in-sample decades.

4.2 Projection results: Income convergence prospects in Europe

The different scenarios put forward above are combined for each one of the two European regions defined. Since there are 12 possible scenarios for each region, this results in 144 possible income per capita scenarios for the 28 European countries in our sample.[3] The simulated income per capita paths allow us to assess the income convergence prospects of EM-11 in the forthcoming decades, as well as the differences existing across individual economies.

[3]We use the estimated fixed effects to obtain our income projections. In principle, other scenarios may have been implemented based on potential changes in, for example, institutional variables which could be thought of as being captured by these fixed effects.

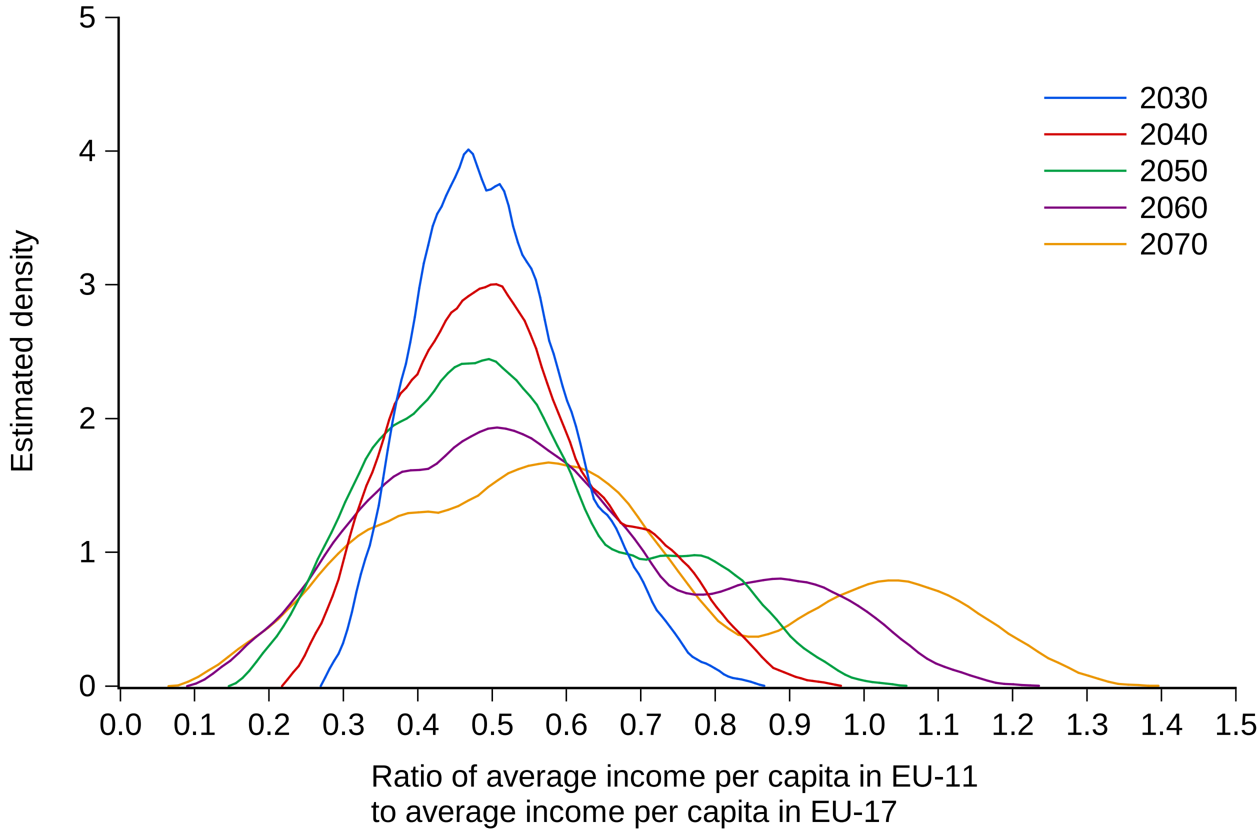

Figure 2: Kernel density of ratio of average income per capita in EM-11 to average income per capita in EU-17 based on projections for all scenarios

Figure 2 presents the kernel density estimates for the ratio of average income per capita in EM-11 to average income per capita in EU-17 using all simulated income per capita paths and evaluated at the projection years 2030, 2040, 2050, 2060 and 2070. The increase in uncertainty concerning income levels is visible from the increasing variance of the distribution of income per capita ratios as the projection period advances. Furthermore, the birth of a bimodal distribution corresponding to strong versus weak income convergence scenarios can be observed from 2050 onwards. On average for the whole EM-11 group, income convergence appears more likely as the projection year increases. This result is in line with the existing empirical results in the literature, which have consistently shown that income dynamics in Europe (and in the EU in particular) are consistent with the existence of convergence in income levels over time (see for example the results in Sala-i-Martin (1996), Henrekson et al. (1997) or Crespo Cuaresma et al. (2008)).

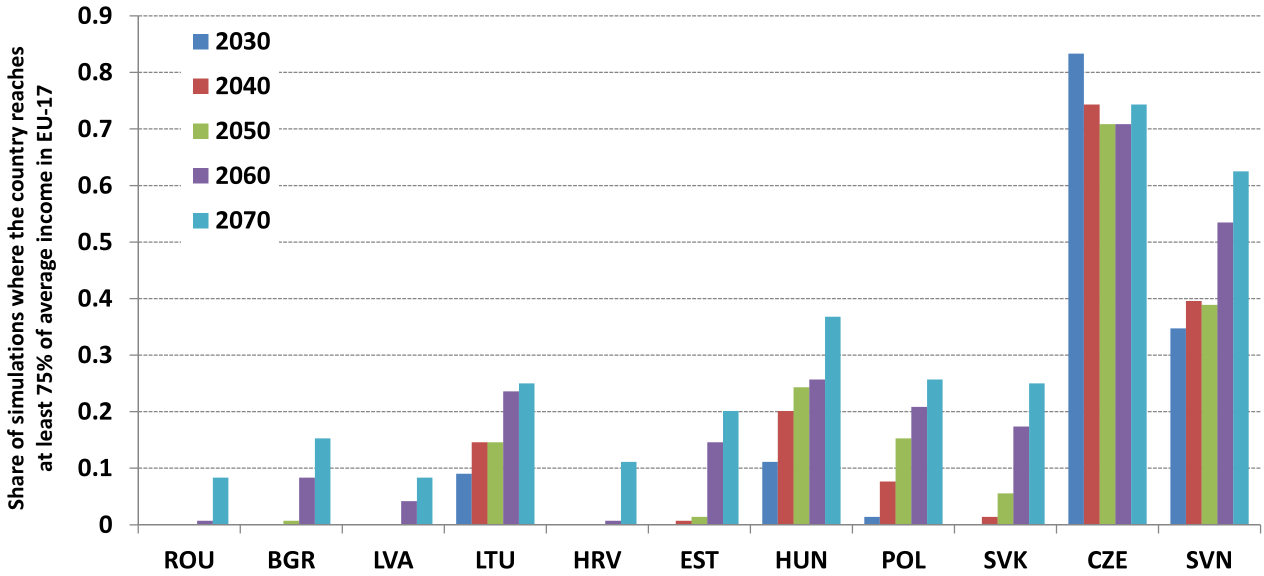

Figure 3: Share of simulations where the country attains at least 75% of average income per capita in EU-17, by projection year

The average results presented in Figure 2 hide a considerable amount of variation across countries in terms of income convergence dynamics in the projection years. In Figure 3 we present the proportion of simulated income paths for each country in EM-11 which resulted in an income per capita above 75% of the average income per capita in EU-17. This proportion is reported for the years 2030, 2040, 2050, 2060 and 2070. EM-11 countries in Figure 3 are ordered by income per capita in 2010. As expected, there is a positive correlation between initial income per capita and the probability of achieving convergence (as approximated by the proportion of simulations achieving at least 75% of income per capita in EU-17) which ranges between 0.71 for the 2030 horizon to 0.84 for 2070. However, there are exceptions to this overall relationship which deserve deeper scrutiny. After taking into account the differences in initial income, the convergence probabilities are particularly low for Latvia, Croatia, Estonia Poland and the Slovak Republic. The Czech Republic, on the other hand, presents the highest proportion of convergent scenarios for all projection horizons.

Since the only projection assumption which is country-specific refers to the developments in educational attainment in the respective economy, for a given level of income the differences across countries in terms of convergence probabilities can be mainly traced down to the dynamics of human capital and its interaction with the rest of the variables in the projection model. In order to quantify the role played by human capital accumulation in the convergence prospects of emerging economies in Europe, we slightly modify the simulation scenarios and construct two alternative settings which embody, respectively, advantageous and a disadvantageous developments for EM-11 in terms of human capital accumulation.

In the first alternative scenario (human capital advantage for EM-11), we repeat the simulations as described above but use exclusively the Constant Attainment Scenario for EU-17 and the Global Education Trend scenario for EM-11. Such a setting results in scenarios where EM-11 countries tend to improve their human capital in terms of the share of working age population with higher educational attainment levels, while investment in human capital by EU-17 countries is just enough to keep these shares constant. The path of improvement of human capital in EM-11 economies is given by the country-specific projections using KC et al. (2010)'s projection method based in the Global Education Trend scenario and as such it depicts realistic improvements based on the historical experience of developed countries. The second alternative scenario, on the other hand, applies the Global Education Trend scenario to countries in EU-17 and the Constant Attainment Scenario to EM-11. Stagnant human capital developments are thus assumed for emerging economies in the EU, while we project further improvements for the rest of the region.

Figure 4 shows the different estimated kernel densities for the ratio of average income per capita in EM-11 to average income per capita in EU-17 in 2050 under these two scenarios, together with the benchmark obtained using all combinations of assumptions, as in Figure 2. The differential gain in terms of the likelihood of convergence from human capital investment for the EM-11 region is visible in Figure 4, with large shifts of the estimated density to the right for scenarios implying high levels of income in this group of countries. While this result indicates that on average further investment in education offers positive returns in terms of improving income convergence in the region, the question remains concerning which countries benefit most in this respect from improvements in human capital accumulation. To answer this question, we calculate for each scenario setting and each country the proportion of income projections where convergence (defined as attaining an income per capita of at least 75% of the EU-17 average) is achieved. We compute the increase in convergence probability from the benchmark implied by computing the scenario where EM-11 has a human capital advantage and interpret such a measure as the potential in terms of income convergence that can be gained from extra human capital investments in the region.

In Figure 5 we present three scatterplots where the corresponding increase in convergence probability is depicted against the initial income per capita for all EM-11 economies for the projection years 2030, 2050 and 2070. The scatterplots suggest that it is relatively richer countries in the region which on average benefit first from extra improvements in human capital, while the return of such investments for relatively poorer economies takes significantly longer. Several exceptions to this overall trend are worth mentioning. The convergence prospects for the Slovak Republic and the Czech Republic, for instance, do not appear to be affected in the first part of the projection period, while at this horizon Lithuania and Slovenia can rip large convergence returns from investments in human capital. For the group of lower income economies in the region the realization of income convergence improvements takes place at longer horizons. The scatterplot in Figure 5 for the year 2070 shows the corresponding negative relationship between the initial income per capita and the increase in convergence probabilities from human capital investment advantages for EM-11 economies.

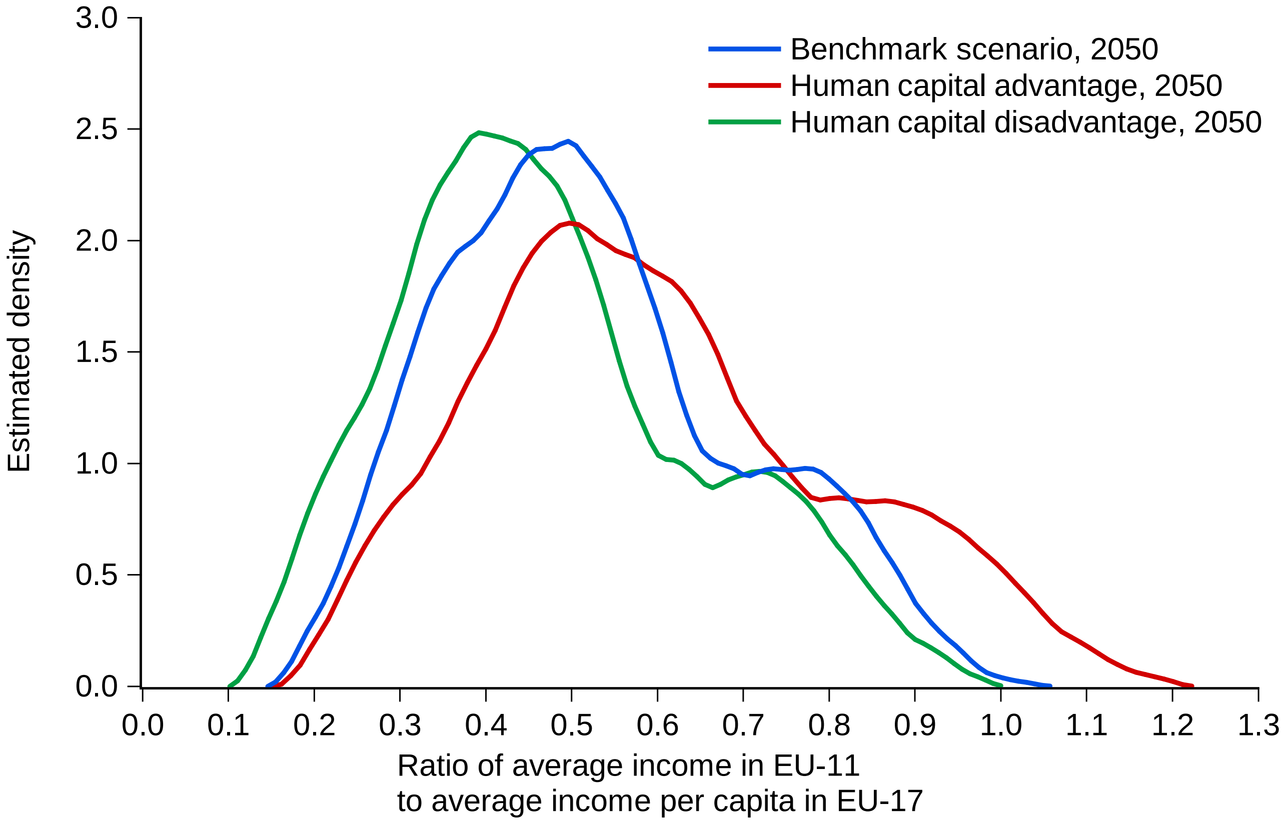

Figure 4: Kernel density of ratio of average income per capita in EM-11 to average income per capita in EU-17 in the projection year 2050: Benchmark scenario and scenarios based on human capital advantage/disadvantage for EM-11

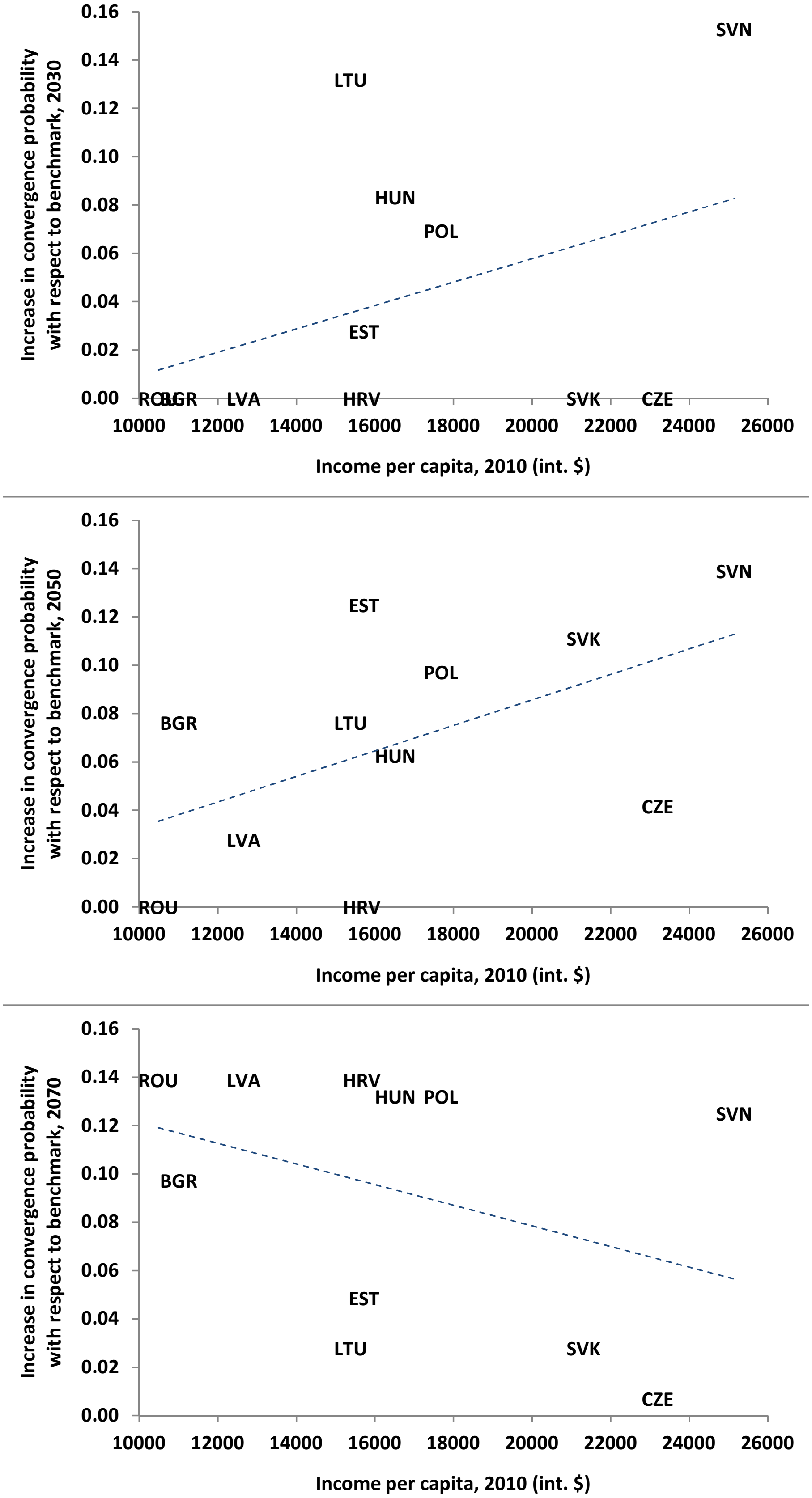

Figure 5: Increase in convergence probability from human capital gains versus income per capita in 2010 for EM-11 countries

5 Conclusions

The development of capabilities that allow emerging economies in Central and Eastern Europe to improve productivity and create new technologies (as well as to adopt technologies developed abroad) is a key factor to ensure further income convergence in Europe in the future. As recognized by the existing empirical literature, the recent economic crisis created a significant pressure on innovation policies to sustain innovation capabilities in European emerging economies, thus potentially jeopardizing future convergence prospects in the region. Technology adoption potential and technology innovation potential are both affected by human capital developments and therefore assessing human capital accumulation plays an central role when assessing convergence prospects for emerging Europe.

We show that tertiary education has a significant effect on income developments by expanding the technology adoption and innovation potential of economies in Europe. A bimodal distribution of income convergence scenarios as well as a significant shift in the estimated income per capita density for human capital advantage scenarios suggests that human capital dynamics have a sizeable effect on future economic growth prospects for Central and Eastern Europe. Even though there are big gains for poorer countries from investments in education, it may take relatively long for these benefits to materialize in the form of accelerated income growth. Long-term oriented policies appear thus necessary in these countries to rip the beneficial growth effects from educational improvements.

The income projection model presented in our study has the advantage of relying on a relatively small set of inputs of production, which allows for the creation of realistic scenarios for human capital developments making use of demographic methods of population projection. Generalizations of such a model, including more complex insights to the creation of new technologies, for example by including research and development spending as an additional factor of production, can prove useful to address other related questions in future research concerning policy choices and economic growth.

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