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Alan Bobetko, Ivana Draženović and Josip Funda

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Croatian National Bank

Abstract

Human capital has long been in the focus of economic growth theory and empirical evidence suggests that better skilled and more educated workforce is one of the prerequisites of higher economic growth. However, due to data constraints, empirical research for emerging market and especially Central and Eastern European countries is rather scarce. Against this background, the paper examines relationship between human capital and economic growth using a cross-section growth regression on a sample of 25 emerging market countries during the 1995-2015 period. Since there is no consensus in the literature about the proper measure of human capital, several different indicators are introduced in our model. We show that there is a strong positive relationship between the level of human capital and economic growth when former is proxied by some measure of cognitive skills. The amount of time spent in school is not statistically significant once the cognitive skills measures are introduced. The results are robust to different model specifications, which include other variables relevant for economic growth such as quality of institutions, openness of the economy and strictness of market regulation. Our simulations show that even if the education reforms are introduced over a very long period and lead to a medium size effects on cognitive skills, this could still have a sizable effect on the level of GDP in the long run.

Key words: *human capital, quality of education, economic growth, emerging markets*
JEL codes: *I25, O47*

***** This Working Paper should not be reported as representing the views of the Croatian National Bank (HNB). The views expressed are those of the authors and do not necessarily reflect those of the HNB. E-mails: alan.bobetko@hnb.hr, ivana.drazenovic@hnb.hr, josip.funda@hnb.hr

1. Introduction

Human capital has long been in the focus of economic growth theory. Recent empirical evidence suggests that better skilled and more educated workforce is one of the prerequisites for higher economic growth. Human capital can roughly be described as an aggregation of attributes that determine how productive people are in their workplaces and in society in general (Goldin, 2016). It includes not only skills but also numerous personal characteristics. For example, Frank & Bernanke (2007) define human capital as a combination of factors such as education, experience, training, intelligence, energy, work habits, trustworthiness, and initiative that affect the value of a worker's marginal product. However, measurement as well as data availability issues constitute a significant obstacle in attempts to explore in detail implications of human capital on economic growth. This is especially the case when longer time-series are needed, which are for many countries not available. Thus, different indicators of education are applied in empirical research, taking due account of the fact that education is one of the main building blocks of human capital. Earlier studies usually use school attainment and average years of schooling. However, such measures of human capital implicitly assume that different schooling systems around the world result in the same level of knowledge and skills, which is obviously not a plausible assumption. Therefore, recent literature relies on the results of international assessments of mathematics, science and reading skills as a more direct measure of human capital.

Empirical results, largely using data for developed countries, confirmed relevance of human capital for long-term economic growth. On the other hand, empirical literature on the relationship between human capital and growth in developing and emerging market countries is rather scarce, as longer time series for human capital have only recently become available. Against this background, in this paper we empirically assess the role of human capital in explaining the variation in average growth rate for a sample of emerging market countries by exploiting newly available data sources.

Our approach draws on the work by Hanushek and Woessmann (2012) which explored the impact of education on growth by using data on different international achievement test performance as a main proxy for the human capital. Taking advantage of new data available up to 2015, we extend the existing research by including Central and Eastern European (CEE) economies which were mostly left out from previous analyses as comparable economic data for these countries start only from the beginning of the 1990's. In this paper, we employ cross-country growth regressions for 25 emerging market countries[1] for the period between 1995 and 2015. As a measure of human capital, we use average years of schooling in line with the early literature but we then focus on measures that serve as proxies for cognitive skills. Thus, we first use available PISA test scores in mathematics and science and then employ the data from the Altinok, Angris and Patrinos database (AAP), which summarizes the results in different achievement tests in a way that allows for comparability over time and across countries. We

[1] Argentina, Brazil, China, Bulgaria, Chile, Colombia, Croatia, Czech Republic, Estonia, Hungary, Indonesia, Korea, Latvia, Lithuania, Malaysia, Malta, Mexico, Peru, Poland, Romania, Russia, Slovak Republic, Slovenia, Thailand, Turkey.

also use a Human Capital Index as a broader measure of human capital produced by World Economic Forum.

Our results point to a strong positive relationship between the level of human capital and economic growth when former is proxied by some measure of cognitive skills or Human Capital Index. Time spent in school is not statistically significant once the cognitive skills measures are introduced into the model. We also show that the effect of human capital on output growth in CEE countries does not significantly differ from other emerging markets. The results are strongly robust to different model specifications that include other variables deemed important for economic growth such as market regulation, quality of institutions and openness of the economy. The paper is organized as follows. Section 2 reviews the empirical literature that explores the relationship between human capital and growth. Section 3 presents some stylized facts on human capital while Section 4 contains model description and the results. In Section 5 we simulate the GDP effects of improved cognitive skills taking Croatia as an example. Section 6 concludes.

2. Literature overview

Economic theory as well as empirical research emphasise the key role of human capital in driving long run economic performances. The relationship between human capital and economic growth is not treated homogenously in economic theory. Augmented neoclassical growth model developed by Mankiw, Romer and Weil (1992) based on work of Solow (1956) describes human capital as a factor of production whose accumulation drives transitional growth but the long-run growth rate is determined completely exogenously by technological changes. In other words, augmented neoclassical growth model claims that increase in human capital will results in temporarily higher output growth until the new higher level of output is reached. Once that is achieved, the level of human capital has no further impact on growth. On the other hand, endogenous growth theories based on the work of Romer (1990) state that increase in human capital results in permanently higher growth rates of output as advanced human capital could continuously facilitate innovation, dissemination of technology, knowledge spill-over or imitation. In empirical research, both theories have been tested and both point to a positive relation between human capital and growth. However, the magnitude of the impact of human capital on growth differed depending on whether augmented neo-classical or endogenous growth model specifications were applied (see Sianesi and Van Reen (2003) for literature survey).

Apart from different theoretical underpinnings, empirical literature is also heterogeneous when it comes to the measurement of human capital. Standard approach is to use some indicator of education as a proxy for human capital given that education is one of its major building blocks. However, indicators of education also differ.

Early literature uses some sort of indicators of "quantity" of education, like school enrolment rates or average years of schooling. One of the first studies that explored the link between indicators of quantity of education and growth was Barro (1991). Using a cross section growth regression Barro found that the growth rate of output is positively related to school enrolment rates, for a given level of initial GDP per capita. He confirmed this conclusion using a panel data regression with around 100 countries for the period 1960-1990 (Barro (1997)). Other researchers obtained similar findings although estimated magnitudes of the impact of human capital on growth varied. Sianesi and Van Reen (2003) conclude that when taking into account differences in modelling choices and variables used, analysed empirical studies suggest that increasing school enrolment rates by 1 percentage points could lead to an increase in per capita GDP growth of between 1 and 3 percentage points. These studies also implied that strong effect on growth could come from increasing average education in the population by one year.

However, recent research suggests that the average years of schooling or enrolment rates are not a good proxy of human capital. This is explained by the fact that indicators of schooling quantity cannot capture skills and knowledge of a nation’s labour force given that they depend on the quality of education and other factors. As a result, recent empirical studies focused on finding better proxies for labour force skills. Given data availability, studies mainly used different students' international tests scores in explaining the impact of human capital on economic growth.

Hanushek and Kimko (2000) were one of the first who used the results of different international student achievement tests as a measure of labour forces cognitive skills. In an empirical setting where the level of human capital influences economic growth they run a cross country regression relating average GDP per capita growth rate between 1960 - 1990 to the years of schooling, measure of cognitive skills and the initial level of income. They show that cognitive skills have statistically significant and positive impact on economic growth, measured by the international student achievement tests, with a higher magnitude compared to a coefficient of quantity of education. When other growth relevant variables were included in the model, labour force quality remained statistically significant and the size of the coefficient stable, while, on the other hand, school quantity becomes statistically insignificant. Overall, their research implies that one country-level standard deviation higher test performance would yield around one percentage point higher annual growth rate. Similarly, a study by Barro (2001) also suggests that while both quantity of education and cognitive skills matter for economic growth, skills are much more important. He estimated that one standard deviation increase in test scores would raise the growth rate on impact by 1 percent per year compared to just 0.2 percent per year for a one-standard deviation increase in educational attainment. Jamison, Jamison and Hanushek (2007) draw on the work of Hanushek and Kimko (2000) updating it with most recent data available and extending the number of countries and control variables. They confirm the importance of cognitive skills on growth. Hanushek and Woessmann (2008) further extend the existing empirical research by using a new series of cognitive skills for 50 countries over the period 1960 - 2000 and came to the similar conclusions.

Appleton et al. (2008) argue however that coefficients stated by Hanushek and Kimko (2000) could be overestimated because they neglect the fact that many countries only participated on international tests in later years of the period under consideration implying that growth rates at earlier dates are linked to recent test scores. In a panel framework and by relating economic growth to lagged test scores they found a positive but significantly lower effect of human capital on growth.

Concerns have also been raised about whether cross-country growth regressions properly identify the causal relationship between dependent and independent variables, as there is a possibility of reverse causality between output growth and explanatory variables, in particular human capital. For example, higher growth can result in an increased resources for education, and, thereby, increase the level of human capital. In order to address this issue, Hanunshek and Woesmann (2012) performed number of additional robustness analyses. They apply alternative model specifications, use different instrumental variables for human capital indicator and specifications where applied test scores predate the growth period under consideration. They conclude that there is no evidence of a presence of reverse causality between output growth and human capital. This conclusion is also supported by the finding of Hanushek and Woessmann (2011) which state that additional educational spending is not systematically related to improved test scores. Altinok and Aydemir (2016) come to the similar conclusions in their study, which compared to Hanushek and Woessman (2012) use extended dataset of international test scores both in terms of countries and period under analysis. This extended dataset is also additionally adjusted in order to address possible measurement errors in indicators of schooling quality. They also come to the similar results in terms of the magnitude of the coefficients. They conclude that one standard deviation increase of cognitive skill measure may increase economic growth by about 1 percentage point and that the effect is higher for developing countries.

3. Human capital: some stylized facts

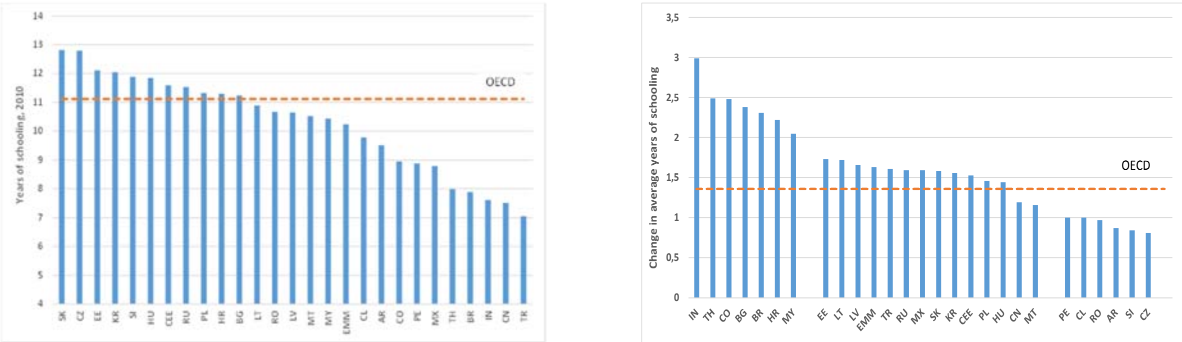
As the main aim of the paper is to evaluate the importance of human capital in economic growth of emerging market countries during the last twenty years, this chapter gives a short overview of the human capital indicators used later in the empirical estimation. However, one has to stress that data availability issues are indeed most pronounced for developing and emerging market countries and therefore the list of potential indicators of human capital was to some extent limited.

In line with the early literature, average duration of schooling was used as an indicator of the "quantity" of education of the countries' workforce. It could be considered as a superior indicator compared to the school attainment (another indicator sometimes found in the literature) as it takes into account differences in duration of mandatory school education (e.g. 8-years vs. 9-years primary education). Furthermore, it implicitly assumes that school dropouts might acquire some additional skills even though they do not obtain the final degree at that level.

Average duration of schooling in 2010, last year for which data are available in Barro and Lee database, was 10.2 years in countries in our sample, which is below OECD average. However, average duration considerably differed across countries. For example, in most CEE countries average duration in the observed period was almost twelve years, with Czech Republic and Slovak Republic recording the highest durations (12.6 and 11.9 respectively). On the other hand, in Thailand, Indonesia and Turkey average years of schooling were around half as low. In all countries average duration increased between 1995 and 2010 and the rise was most notable in countries with the lowest starting years of average schooling - especially in Indonesia, Thailand, Brazil and Columbia –pointing to a rising awareness of importance of education for development. Namely, average duration of schooling increased by 3 years in Indonesia, and by around 2.5 years in Thailand, Columbia and Brazil. Among CEE countries, strong increase of more than two years was recorded in Bulgaria and Croatia, which raised their average schooling years to more than eleven years and it is now at the average level of OECD countries.

Figure 1. Average years of schooling

a) Level in 2010. *b) Difference between 2010 and 1995*

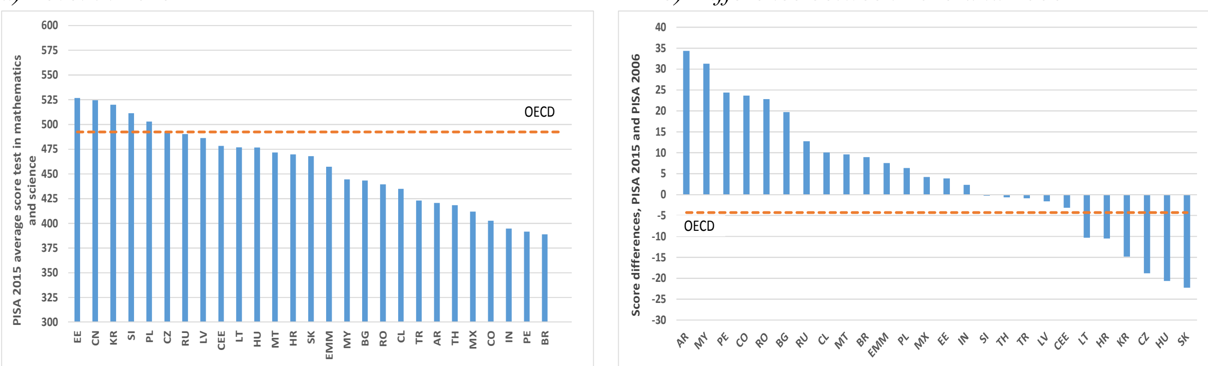


Source: Barro and Lee 2010 database, available on www.barrolee.com

Slightly more heterogeneous developments can be observed when it comes to PISA average mathematics and science test performance that we use as measure of cognitive skills in our cross-country regression. According to the last available data for 2015, emerging market countries achieved on average 457 points which is considerably lower compared to OECD average (492 score points). From countries in our sample, Estonia had the highest average score in mathematics and science tests, followed by China, Korea, Slovenia and Poland (all above 500 points). On the contrary, Brazil, Peru and Indonesia had the lowest score, which was more than 100 points below OECD average. However, looking over time, in roughly half of the countries in our sample average achievement on PISA test was higher in 2015 compared to 2006. In particular, Argentina and Malaysia achieved the highest improvement, followed by Peru and Colombia. In the rest of the countries in our sample, the results on PISA test either remained the same or worsened compared to 2006. Most notable declines were recorded in CEE countries, namely Slovakia and Hungary, followed by Croatia and Lithuania.

Figure 2. Cognitive skills measured by PISA test results

a) Level in 2015 *b) Difference between 2015 and 2006*

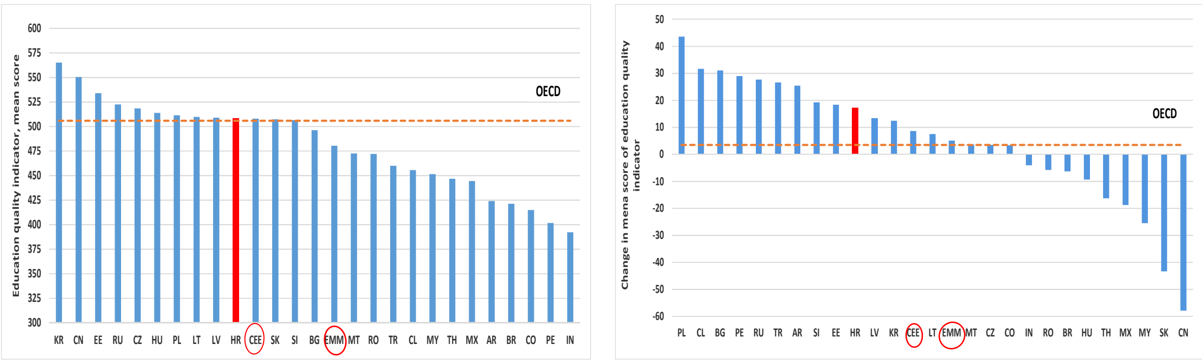


Note: Data for China are available only for 2015.
Source: OECD

Besides PISA, education quality indicators from AAP database can be used as another measure of cognitive skills. While mentioned dataset is richer in information compared to PISA as it includes standardized scores in different students' achievement tests[2] from 1965 to 2015, it points to the similar results for our sample of countries. Top performers again include Korea, China and Estonia while Colombia, Peru and Indonesia are at the bottom of the list. On average, emerging market countries significantly lag behind OECD countries. This is however not the case for emerging markets from the CEE region whose results are slightly above the OECD average. Looking at the developments over the last decade one can notice that around two thirds of emerging market countries in our sample increased their mean score. In particular, Poland managed to achieve the largest improvement, followed by Columbia, Peru and Bulgaria. On the other hand, the biggest drop in mean score was reported for China.

Figure 3. Cognitive skills measured by test scores from AAP database

a) Level in 2015 *b) Difference between 2015 and 2005*



Note: data for China are available only from 2010.
Source: AAP database available on https://sites.google.com/site/nadiraltinok/home/datasets

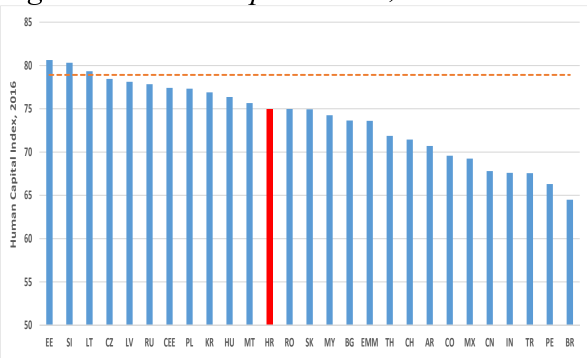
Taking into account that education is only one of the building blocks of human capital, World Economic Forum has developed a more comprehensive measure of human capital, the so-called Human Capital Index (HCI). This indicator goes beyond educational indicators and incorporates broader set of measures, which are considered to contribute to the capacity of population to drive economic growth. In total HCI includes 46 indicators distributed over two themes – learning and employment – and across five age groups. Besides educational attainment indicators and measures of the quality of education, HCI includes indicators such as labour force participation rate, incidence of long-term unemployment, incidence of overeducation, ease of finding skilled employees, etc. Human Capital Index measures countries "distance to the ideal state" on a scale from 0 (worst) to 100 (best). Unfortunately, although HCI offers important insights about human capital, its time series is rather short as it was first published only in 2013.

Figure 4 shows the level of HCI for countries in our sample. The highest level of HCI in 2016 was found for Estonia and Slovenia, implying that those countries have the best practice in

[2] The dataset is constructed using the results from several international tests (FIMMS, SRC, FISS, SIMS, SISS, RLS, TIMMS, PIRLS and PISA) and regional level test (LLECE, SACMEQ and PASEC) for 164 countries and administrative regions for period between 1965 and 2015. Applying different linking methodologies, the authors have achieved data comparability over time and across countries.

developing and deploying human capital potential. On the other hand, Peru and Brazil were at the lower end. Average score of HCI in CEE countries was relatively similar to the average for the OECD countries.

Figure 4 Human capital Index, 2016

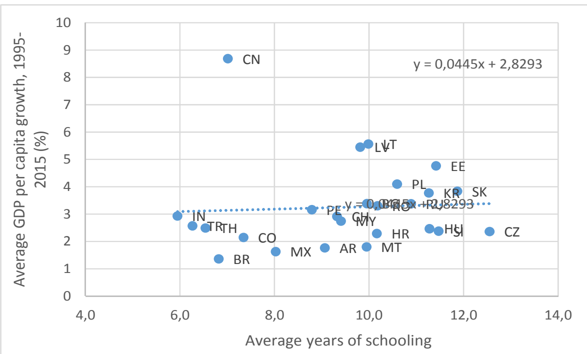


Source: World Economic Forum

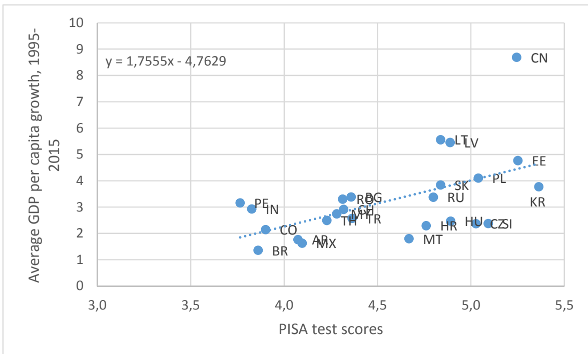
Figure 5 illustrates a simple relation between our measures of human capital and growth in real GDP per capita between 1995 and 2015. It can be seen that there is positive correlation between all four measures of human capital and GDP growth. However, it seems this relationship is weak for average years of schooling (panel a), probably due to usual drawback of this measure of human capital mentioned in the literature. On the other hand, correlation is much stronger when human capital is proxied by direct measures of cognitive skills or HCI. This will be econometrically tested in the chapter that follows.

Figure 5 Human capital measures vs. economic growth

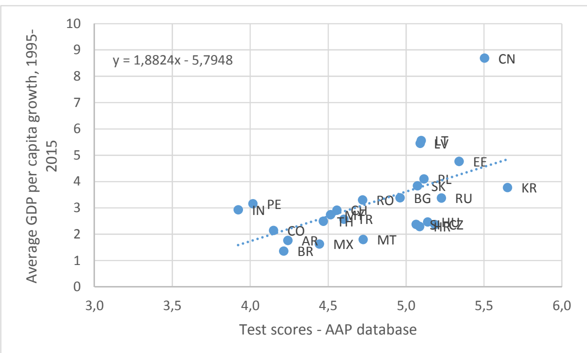
a) Average years of schooling



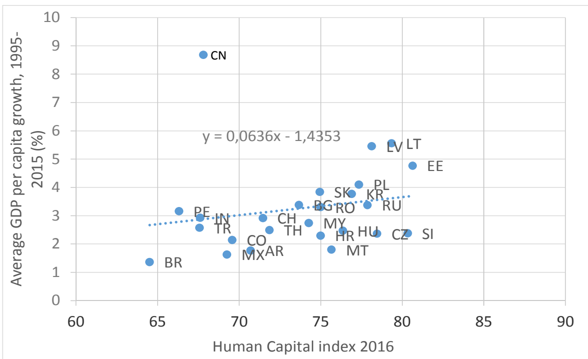
b) Pisa test scores



c) Test scores – from AAP database



d) Human Capital Index



Source: authors' calculation

4. The model specification and the data

4.1. Model specification

Our empirical strategy relies on a cross-sectional growth regression based on Hanushek and Woessmann's (2012). Our model specification takes the following form:

$$g_i = c + \beta_1 GDP_i + \beta_2 H_i + \beta_3 X_i + \varepsilon$$

where g_i denotes GDP per capita annual growth in the country i, *GDPi* denotes the initial level of GDP, H_i is the measure of human capital, X_i is a vector of other explanatory variables, *c* is constant term, and ε is an error term.

The first model specification is a simple growth regression that assumes that the average long-term growth rate is positively related to the level of human capital and negatively with the initial level of GDP. In other words, countries with higher level of human capital will tend to have higher growth rates. This assumption draws on the endogenous growth theory and the work of Romer (1990) who sees human capital as an input that leads to innovation and, finally, to technological change. Therefore, the level of human capital is what affects the rate of GDP growth. We also test for the convergence hypothesis in line with neoclassical growth models (Solow, 1956; Mankiw et al., 1992) which assumes income-level convergence among countries; i.e. relatively poorer countries will grow faster than richer ones.

We extend the basic model with additional variables considered to be important for the long-term growth. We include proxy for trade openness, as, according to the theory, there are numerous potential gains from trade liberalization. This is especially the case for developing and emerging market countries where increased openness could spur growth through technology diffusion, transfer of knowledge and increased competition. Furthermore, we control for the potential impact of institutional quality and the strictness of market regulation in respective countries. Empirical evidence suggests that good institutions are conducive to growth (Hall and Jones (1999), Acemoglu, Johnson and Robinson (2001, 2002)). Protection of property rights, efficient bureaucracies and other features of good institutions create conditions that foster investments and economic growth. When it comes to product market regulation, empirical studies (Levy&Spiller (1994), Parker et al. (2007)) suggest that more regulated markets could result in misallocation of resources and hinder innovation and investment with an overall negative impact on growth.

Notwithstanding the introduction of additional explanatory variables that are highlighted in empirical literature as important growth determinants, the risk of omitted variable bias is still present. Durlauf et al. (2005) have provided a list of almost 150 explanatory variables used in different studies. They conclude that when accounting for different measurement of essentially identical explanatory variables literature suggests 43 distinct growth determinants that have been found statistically significant in at least one study.

Some studies have used panel data methods with fixed effect estimator in order to, among other things, account for the omitted variables that do not change over time. However, such approach exploits information from within-country variation while between-country variation is neglected. Given that some explanatory variables are highly persistent and do not change much over time, between country differences are usually dominant source of information. As a result, the reduction in bias in panel data studies typically comes at the expense of higher standard errors, which means higher imprecision of parameter estimates (Durlauf et al. (2005). Moreover, annual changes of economic growth or changes over short period of time are usually under the influence of the business cycle which can impede the assessment of long-run growth determinants. As a result, panel data studies use data that has been averaged over five or ten year period, however, given this is still relatively short time span it is highly questionable whether this problem has been properly addressed as opposed to cross country regression where data is averaged over 20 and more years. Data averaging over five and especially ten-year periods also leaves relatively small number of time periods to investigate.

The data

Dependent variable: GDP per capita annual percentage growth, measured in real terms, for country *i* over the period 1995-2015.

Independent variables:

Initial level of GDP: GDP per capita in 1995 in constant dollar terms.

Human capital:

(i) Average years of schooling of population aged 15 years and older in the 1995 -2010 period extracted from Barro and Lee database,

(ii) Average PISA test scores in mathematics and science. Comparable PISA test scores in mathematics are available from 2003 and in science from 2006 to 2015, with participation of some countries only in later years. We use the averages of available data. This measure implicitly assumes that cognitive skills of students are a good proxy for cognitive skills of the workforce.

(iii) Test scores from AAP database (2017)

(iv) Human Capital Index. Overall index for 2015.

Trade openness: Average share of export and imports in GDP between 1995 and 2015,

Quality of institutions: Average of six aggregate World Bank Governance Indicators over 1996 - 2015 period.

Product market regulation: Average of Doing Business sub-component index - Starting a Business - between 2004 and 2015.

4.2. The results

The results of the cross country growth regressions are presented in Tables 1-3.[3] Model specifications are the same in all three tables but besides average years of schooling, they differ in human capital measure included in the model (PISA test scores, test scores from AAP database and HCI).

Following the early literature on human capital and economic growth nexus, first model specification measures human capital by average years of schooling and includes initial GDP per capita to test the convergence hypothesis. The results presented in Table 1 all have expected sign and are statistically significant. They show that countries that have started at the higher level of output per capita grew slower and that additional year of schooling increases growth by 0.4 percentage point (column 1 in Table 1). However, as previously explained, using years of schooling as a measure of human capital has been strongly criticised in the literature because this essentially assumes that one additional year of schooling in different countries around the world has the same effect in terms of cognitive skills.

Therefore, second model specification includes test scores (Tables 1 and 2) or HCI (Table 3) as a proxy for human capital. Once such measure is included in the model as an additional variable, explanatory power of the model significantly increases. The average years of schooling variable is no longer statistically significant while the initial GDP level coefficient does not change much and remains statistically significant. Other human capital proxies are strongly statistically significant and have a high positive effect on growth (column 2 in Tables 1-3). In line with the results, in specifications 3-7 we drop average years of schooling from further analysis. Our results show that the estimated coefficient on human capital is high and statistically significant irrespective of the test scores used in the estimation (PISA scores vs AAP database). In other words, results of specification 3 indicate that one standard deviation higher test scores at student level results in around 2 percentage points higher growth. This is equivalent to 1.1 percentage point higher growth for one standard deviation higher test scores at the country-level. Similarly, results in the Table 3, which uses HCI as a proxy for human capital show that one standard deviation higher HCI at country level would increase GDP growth by 0.9 percentage points.

We expand specification 3 with additional variables that are often found to be relevant for growth in the long run. We test whether any variable that measures countries' conduciveness for doing business (market regulation and quality of institutions) and openness helps to explain growth differences among countries in the sample. The results show that product market regulation and openness are not statistically significant and even have the wrong sign (columns 4 and 5). On the other hand, when institutions are added to the model they have statistically significant positive impact on growth and coefficient on cognitive skills declines. In this model specification (column 6), results based on PISA test scores indicate that one standard deviation higher test score at student level increases growth by 1.85 percentage points, while coefficient on cognitive skills, which uses AAP database drops to 1.57 (equivalent to 0.9 and 0.7 for one standard deviation higher test scores at the country-level) Specification with HCI indicator shows that one standard deviation increase in HCI at the country level increases growth by 0.7 percentage points. In our last specification, given our interest in CEE countries and in order to

[3] Estimates are based on robust least squares estimation implemented in Eviews that take into account outliers in both dependent and independent variables.

allow for parameter heterogeneity, we add interaction term between CEE dummy and cognitive skills. We cannot confirm that cognitive skills have significantly different impact on growth in CEE countries.

The estimated effects of test scores are very similar to those found in the empirical literature (e.g., Hanuskek and Woessmann (2012)), while magnitude based on HCI is somewhat lower. However, these coefficient need to be interpreted with caution given limited number of countries under analysis and econometric issues (reverse causality, omitted variable bias, parameter heterogeneity) which characterize cross country regressions.

Table 1. The results of different model specification based on PISA test scores

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Average years of schooling	0.408***	-0.108	-	-	-	-	-
	(0.116)	*(0.127)*					
Test scores 1	-	2.908***	2.322***	2.767***	2.299***	1.849***	1.950***
		(0.439)	*(0.314)*	*(0.376)*	*(0.356)*	*(0.283)*	*(0.312)*
Initial GDP per capita	-0.199***	-0.308***	-0.274***	-0.325***	-0.283***	-0.308***	-0.319***
	(0.061)	*(0.05)*	*(0.04)*	*(0.047)*	*(0.044)*	*(0.044)*	*(0.047)*
Openness	-	-	-	-	-0.097	-	-
					(0.114)		
Quality of institutions	-	-	-	-	-	0.717**	0.776**
						(0.303)	*(0.811)*
Market regulation	-	-	-	-0.021	-	-	-
				(0.024)			
CEE*Test scores 1	-	-	-	-	-	-	-0.034
							(0.064)
No. of countries	25	25	25	25	25	25	25
Rw^2 (adj.)	0.49	0.82	0.76	0.81	0.78	0.83	0.82

All equations include a constant. Standard errors are in parenthesis.
* significant at 10% level; ** at 5% level; *** at 1% level

Table 2. The results of different model specification based on test scores from AAP dataset

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Average years of schooling	-	-0.071	-	-	-	-	-
		(0.158)					
Test scores 2	-	2.574***	2.302***	2.677***	2.039***	1.574***	1.610***
		(0.542)	*(0.398)*	*(0.458)*	*(0.401)*	*(0.318)*	*(0.354)*
Initial GDP per capita	-	-0.256***	-0.254***	-0.283***	-0.240***	-0.289***	-0.294***
		(0.065)	*(0.052)*	*(0.054)*	*(0.049)*	*(0.051)*	*(0.055)*
Openness	-	-	-	-	-0.183	-	-
					(0.130)		
Quality of institutions	-	-	-	-	-	0.965***	1.001**
						(0.342)	*(0.398)*
Market regulation	-	-	-	-0.032	-	-	-
				(0.029)			
CEE*Test scores 2	-	-	-	-	-	-	-0.015
							(0.072)
No. of countries	-	25	25	25	25	25	25
Rw^2 (adj.)	-	0.71	0.69	0.73	0.71	0.76	0.76

All equations include a constant. Standard errors are in parenthesis.
* significant at 10% level; ** at 5% level; *** at 1% level

Table 3. The results of different model specification based on Human Capital Index

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Human Capital Index	-	-	0.194***	0.205***	0.179***	0.150***	0.156***
			(0.039)	*(0.049)*	*(0.041)*	*(0.039)*	*(0.050)*
Initial GDP per capita	-	-	-0.201***	-0.207***	-0.198***	-0.275***	-0.279***
			(0.050)	*(0.053)*	*(0.050)*	*(0.053)*	*(-6.218)*
Openness	-	-	-	-	-0.124	-	-
					(0.122)		
Quality of institutions	-	-	-	-	-	0.885**	0.911**
						(0.391)	*(0.423)*
Market regulation	-	-	-	-0.012	-	-	-
				(0.029)			
CEE*Human Capital Index	-	-	-	-	-	-	-0.001
							(-0.581)
No. of countries	-	25	25	25	25	25	25
Rw^2 (adj.)	-	0.64	0.64	0.64	0.66	0.73	0.73

All equations include a constant. Standard errors are in parenthesis.
* significant at 10% level; ** at 5% level; *** at 1% level

5. Simulation of economic benefits of improved cognitive skills – case of Croatia

The results provide an indication of the impact of the improved cognitive skills on economic growth. However, since the improvement of cognitive skills is usually achieved by raising the quality of education, effects on growth become apparent only with a significant time lag. Namely, implementation of educational reform takes time and it may take decades for the improvements to affect the full labour force. In order to assess the potential implications of improvement in cognitive skills on output in the long run, we complement our econometric analysis with the simulation exercise using Croatia as an example. In the simulation, we follow the approach of Hanushek and Woesmann (2011) and do not assume any reform package but focus on the growth impact of changes in test scores. This also requires several assumptions regarding the timing and the extent of the reform.

As education reforms usually take time, we assume that the reform will be completed 20 years after the starting year, in our case 2018, and that test scores linearly converge to the full assumed effect of the reform. This means that if for example reform results in improvement of 50 points on PISA scale after it is fully completed, annual test score improvement amounts to 2.5 points. Furthermore, work life is assumed to be 40 years, which means that in our simulation only after 2078 new skill levels will apply to the entire labour force. This also implies that we need long term projections of the potential GDP growth that do not take into account cognitive skills improvements. We set 2090 as a last year to trace economic benefits of education reform and for the potential growth forecast until 2060 we use European Commission's long-term growth projections assuming that output gap in 2018 linearly closes by 2025. After 2060, potential growth is assumed to remain constant. In order to assess the total effect of the reform in present value terms, we sum annual discounted future gains (difference between GDP with and without reform) by using a discount factor of 3%.

When it comes to the effects of the reform, our baseline simulation scenario assumes that the reform will results in 25 point increase on PISA scores which is equivalent to 0.25 standard deviations improvement at student level. Improving by 25 points on PISA scale Croatia would perform near the average of OECD countries. We assume that the estimated coefficient on cognitive skills is 1.57% based on the cross section regression that includes test scores from AAP database and the quality of institutions as additional explanatory variable. This means that quarter of standard deviation higher test score is associated with 0.4 percentage points higher long run annual growth rate. As noted, in our simulation scenario full effect on annual growth compared to the baseline will be evident only after year 2078 when all people in the labour force are assumed to have acquired improved skills, which can be seen in Figure 6.

Figure 6 Difference in growth rates

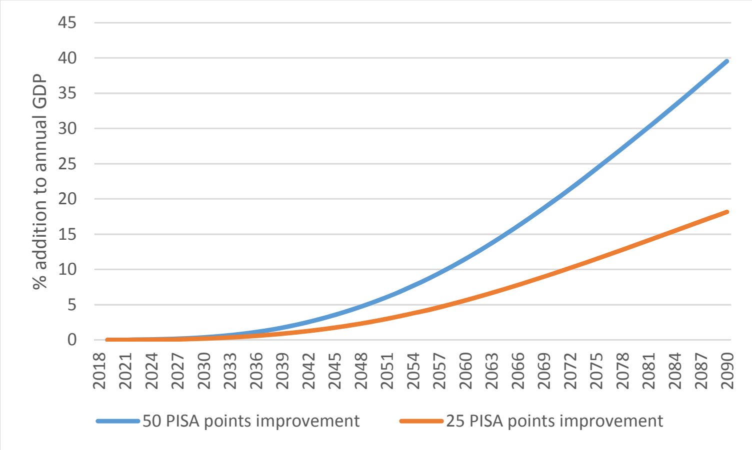
Source: authors' calculations

Results show that although difference in annual growth rate compared to baseline estimates throughout forecast horizon is not large, accumulation of economic benefits over time results in sizable GDP gains. In 2060 GDP is 5.6% higher compared to baseline estimates and in 2090 difference increases to 18.2%. It is important to note that benefits continue also into the future. Moreover, when looking at the cumulative impact on the economy until 2090 the future discounted benefits amount to 145% of current GDP.

If Croatia would pursue a more ambitious goals like improving cognitive skills by half a standard deviation, which would bring Croatia close to the level of top performers, the economic benefits would be quite substantial.[4]

[4] In 2060, GDP could be 11.5% higher compared to baseline estimates and by 2090 difference could increase to almost 40%. The future discounted benefits could amount to around 300%.

Figure 7 Effect of education reform on GDP level



Source: authors' calculations

6. Concluding remarks

Theoretical models and empirical estimates have confirmed the importance of human capital for long-term growth. There is however still an ongoing debate about the most appropriate measure of human capital as it is being built through education, experience, training, etc. While the early works revert to school attainment, recent studies emphasize the importance of the quality and use the achievement on different internationally comparable tests as a measure of human capital. Furthermore, the estimates of the return to human capital differ considerably in the empirical literature but clearly point to a positive relation.

In this paper we have analysed developments in human capital in 25 emerging market countries and estimated its importance for explaining the variation in average growth rates for the past twenty years controlling for the starting level of development and other possible factors. The data show that when it comes to average years of schooling emerging markets in Central and Eastern Europe are either close or even above OECD average. On the other hand, countries in Asia and Latin America (Korea being a notable exception) are still below the OECD average but have made some progress in 1995-2015 period. However, when it comes to the cognitive skills measured by the results in PISA test in math and science, developments are less positive. Most of the countries in our sample achieve worse results on these tests compared to developed countries and the results in many of them have deteriorated over the past twenty years, especially in the CEE region.

Such developments are even more worrisome when one takes into account the results of our cross-sectional growth regressions. Namely, we show that cognitive skills have strong positive effect on growth. Furthermore, once cognitive skills measure is included in the equation, school attainment becomes insignificant suggesting that it is the quality of human capital, in other words skills attained during education and work-life, what matters for economic growth and not time spent in the school system. The results are robust and coefficients stable once different control variables are included in the model (e.g. openness, quality of institutions and market regulation).

While the positive relation between human capital and growth is plausible, the size of the coefficient is somewhat questionable, even though in line with recent literature. Namely, our estimates suggest that an increase in PISA test of 100 points could raise average GDP per capita growth rate by around 2 percentage points that seems quite high. In addition, due to likely lagged effects of education on the quality of the labour force, panel data analysis might be more appropriate than simple cross sectional growth regression but insufficient data precludes us from following this empirical strategy.

Despite these drawbacks, several policy conclusions might be drawn from the results. Policymakers should try to avoid short-sighted measures and focus their efforts on raising the quality of all levels of education and foster whole-life learning. This should have a positive impact on the labour productivity and output growth in the long-run. Our simulations show that even if the education reforms are introduced over a very long period and lead to a medium size effects in terms of cognitive skills, this will still have a sizable effect on the level of GDP in the long run.

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