ARE STUDENTS' ACHIEVEMENTS IN THE EU COUNTRIES EXPLAINED BY INVESTMENT IN CHILDREN AND YOUTH?

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Abstract

In the paper we analyse whether the students' achievements in reading and mathematics are linked to the level of Human Capital investment in children and youth as well as the level of human development in the countries. We assess the public Human Capital investment (for education, health-care as well as other public consumption) from birth to age 15, using the National Transfer Accounts methodology. This quantitative measure of investment in Human Capital is compared with the results of international assessment of competencies of 15-year olds of 24 European Union countries, that participate in Programme for International Student Assessment (PISA) survey of the OECD. Our results indicate that the PISA outcomes are explained by both the level of human development in the country (measured by Human Development Index) and by public Human Capital investment at different stages of children's life course: earliest (age groups 0-3), pre-primary and primary education (ages 4-12) and lower secondary education (ages 13-15). Focus on the investment in the oldest age group seems to be most significant for students' achievement in PISA

Key words: human capital, returns to schooling, national transfer accounts

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Introduction

Given the high importance of skills for development, there is a growing body of research related to the development of skills as well as links between skills and economic growth. Foundation skills are developed at early stages of life course. This is investigated, among others by (Heckman, 2003, 2008). Heckman underlines that human capital is an investment good and devising effective policies in this area should take into account for the life course dynamics of learning and skills acquisition. The concept of human capital is also more and more used by the economists in explaining aggregate variations in the well-being of nations. Individuals and governments make investments in skills that have later payoffs in outcomes that matter (Hanushek & Woessmann, 2013).

The research on across countries differences in educational achievements focuses on two main aspects: first, on determinants of these achievements and second on the studies of outcomes (Hanushek & Woessmann, 2013). Many of the studies rely on the use of national data for explaining the observed differences. As (Hanushek & Woessmann, 2013) point out, it is time to consider how these large-scale international assessments could be made even more useful through direct linkage to the larger cross-country research activities.

In our paper, we aim at linking the results of two international research activities: Programme for International Student Assessment (PISA) and National Transfer Accounts (NTA). The NTA is an innovative methodology, which offers the possibility to study the economic life cycle at aggregate levels to improve our understanding of the generational economy (Lee and Mason 2011).

In the paper, we use the NTA assessment of average investment in human capital (public and private) between ages 0 and 15 to analyse in cross-country perspective there is a link between education (and other) expenditure and students' achievements. We expand the earlier work of (Woessmann, 2007) by dividing the human capital investment to different periods in the life course, following the notion of (Heckman, 2008). Our main goal is to assess, whether the level of human capital investment at different stages of life course (early childhood, primary education, lower-secondary education) contribute to the level of students' achievements.

1 Measuring, developing and using skills for economic growth

Early research on human capital concentrated mainly on quantity of schooling (such as school attainment). However, it became more and more obvious that quantity of schooling is not sufficient to understand differences in the skills formation between countries. One of the surveys that is focusing on students' performance on a regular basis is the Programme for International Students Assessment (PISA), performed on the three-year cycle since 2000. PISA is assessing the knowledge and skills of 15-year-olds in more than 60 countries. Given the fact that PISA tests 15-year-olds, the results of this survey can be used to analyse, among others, determinants of skill formation as well as the impact of skills on economic development of countries.

As the international testing shows clearly differences in educational achievement across nations, there is a broad body of research that focuses on seeking the reasons and

determinants of formation of skills and reasons for the observed differences. E. A. Hanushek & Woessman (2010) propose the following form of education production function:

(1) $$T = a_0 + a_1F + a_2R + a_3I + a_4A + \varepsilon$$

Where T is the outcome of the educational process as measured, e.g. by test scores in mathematics, science, and reading. The vector F captures facets of student and family background characteristics, R is a vector of measures of school resources, I is institutional features of schools and education systems, and A is individual (unobserved) ability. Many of these factors are related to individual student level and, as shown in the literature, based among others, on PISA survey, family background is strongly linked to the educational performance.

Cross-country studies on links of international achievement and public investment (in monetary or resource) measures take into account average values across different age and do not take into account age profiles of educational investment or differences in inputs at different educational stages. However, studies on skill formation in the life course perspective show that there are differences in the returns to investment at different ages. Heckman (2003, 2008) presents a model on returns on investment in human capital in such perspective, developed on the findings of an entire literature. In the model, the investment in human capital shows greatest return in earliest years of childhood (0-3), with gradually declining returns in the case of pre-school programmes and schooling.

In our article, we extend the work on analysing the role of public and private investment in human capital development of (Woessmann & Peterson, 2007) by application of the notion of (Heckman, 2008) by assessing, whether the human capital investment at different ages (from 0 to 15 years) explains differences in educational achievement of 15-year-olds.

2 Human Capital in the NTA framework

The NTA approach allows to measure, in internationally comparable manner, the level of public and private consumption for education, health and other purposes by age (Lee and Mason 2011; Population Division. Department of Economic and Social Affairs. United Nations 2013a). In the NTA framework the total consumption is divided according to the following formula:

(2) $$C_i = CF_i + CG_i = (CFE_i + CFH_i + CFX_i) + (CGE_i + CGH_i + CGX_i)$$

where: CFE_i: Private Consumption, Education at age i; CFH_i: Private Consumption, Health at age i; CFX_i: Private Consumption, Other than health and education at age i; CGE_i: Public Consumption, Education at age i; CGH_i: Public Consumption, Health at age i; CGX_i: Public Consumption, Other than health and education at age i.

In the NTA framework, the measure of human capital investment is a synthetic cohort measure constructed by cumulating annual public and private spending on health and education at age 0-17 for health and at age 3-26 for education. The age limits for health were chosen to exclude most health spending on maternal health because of uncertainty about the extent to which that spending enhances the human capital of the mother as compared with the unborn child. Education spending was counted from age 3 to exclude spending on care provided to very young children that is more often commercialized in rich countries than in poor countries (Population Division. Department of Economic and Social Affairs. United Nations, 2013).

Tung (2011) underlines that in the NTA framework education appears as the major channel of human capital investment and amounts on average to 8.09% of total spending for the economies analysed in (Lee and Mason 2011b). In particular, education accounts for a substantial share of the consumption of the young person in many economies, regardless of the level of economic development. In the case of European countries most of the educational spending is made through the public consumption.

Following the approach proposed Heckman (2008) we measure human capital investment as public and private consumption for health and education in ages 0-15. We set the upper age limit is applied based on the age of the youth when PISA test is performed, as shown in the following equation:

(3) $$HC^{15} = \sum_{i=0}^{15} CGE_i + \sum_{i=0}^{15} CGH_i + \sum_{i=0}^{15} CFE_i + \sum_{i=0}^{15} CFH_i$$

To achieve comparability of the results, the consumption is normalised through dividing by average labour income of a person in age group 30-49 years[1], which is a standard normalisation value used in the NTA method. In our sample of 25 EU Member States, the NTA profiles were assessed for the year 2010.

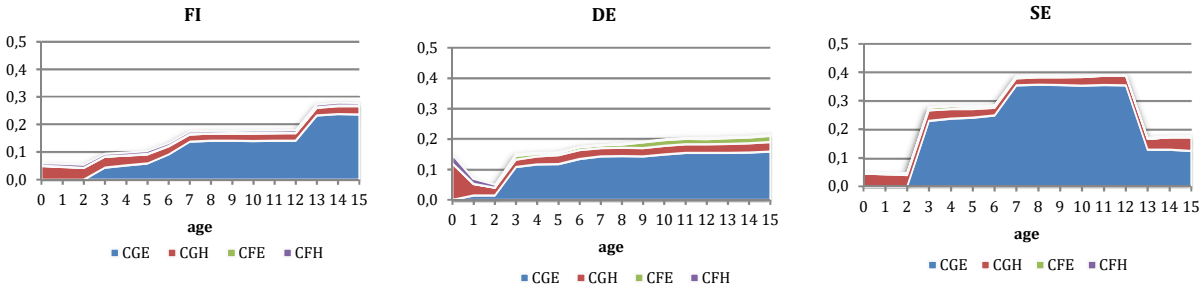
Our results indicate that there is a significant diversity of the relative level of human capital investment. Confirming earlier findings of (Tung, 2011), the consumption for public

[1] This is a normalisation factor applied in the NTA methodology (Population Division. Department of Economic and Social Affairs. United Nations, 2013)

education is the major component of the total human capital investment, ranging between 61% and 86% in the sample.

Countries differ not only by the level of human capital investment, but also by the age profiles of this investment. The age profiles of public education investment differ across countries. In some countries the level of investment increases with stages of the educational system. There are three general profiles that emerge. The first one is characterised education consumption increases at later educational stages (for example Bulgaria, Czech Republic, Finland). In the second profile public education is flat across ages (for example Germany, Hungary). In the third one we see decline in public education consumption after age 12 (for example Sweden, Denmark, Estonia), which is shown in Fig. .

Fig. 1: Three profiles of human capital investment by age in the selected EU countries



Source: Authors' estimation based on the NTA profiles developed in the AGENTA project (www.agenta-project.eu)

It should be underlined that the above measure of human capital investment does not take into account the time investment of parents into the development of children, which is an important contribution to the development of the human capital of children. The evidence in the literature indicates that both money spend on children (e.g. purchasing books, toys) and the time parents spend with them in joint activities (e.g. reading books) are considered investments that have the potential to enhance children's cognitive skills and language (Gershoff et al., 2007) and emergent literacy (e.g. Dickinson & Tabors, 2001). As discussed in the previous section, the family background is an important determinant of educational achievement.

3. Does human capital investment explain differences in PISA results?

In order to assess the role of human capital investment in explaining PISA results in 25 EU countries we propose a model that uses the approach presented by (Woessmann & Peterson, 2007), combined with measuring returns to human investment in the early stages of life

course as proposed by (Heckman, 2008), that can take a non-linear form. In the model, we also control for the overall human capital development by including the Human Development Index (HDI) value in the regression. It is used to capture effects related to cultural capital, level of development as well as some institutional features of school systems in the analysed countries, as proposed in the education production function (1).

We propose the following general model of explaining a dependent variable, that is cognitive skills of 15-year olds in country j $\left(C_j^{15}\right)$ measured by the 2012 PISA score in reading (OECD, 2013)[2] by independent variables including the human development in the country in year 2010 measured by (HDI_j) and the level of investment in human capital (HCI_j^{0-15}) that are made between ages 0 and 15 also measured in 2010. It should be noted that the HCI_j^{0-15} is measured using cross-sectional data and it is not a longitudinal measure. That means that we assume constant profiles of public expenditure on education in time, which is a strong assumption, as discussed for instance (Hanushek & Woessman, 2010)

(4) $$C_j^{15} = F\ (HDI_j;\ HCI_j^{0-15})$$

To take into account different returns to education at different stages of life course, we divided the HCI_j^{0-15} in four stages: early childhood (0-3 years), pre-school (4-6 years), early primary education (7-9 years), later primary education (10-12 years) and lower secondary education (13-15 years). As human capital investment in age groups: 4-6; 7-9 and 10-12 is strongly correlated, we collapse the final set of independent variables related to human capital investment to three periods: early childhood (0-3 years), preschool and primary education (4-12 years) and lower secondary education (13-15 years). Such independent variables are not strongly correlated that allows us to use them in the regression model.

In order to capture the contribution of HCI to explaining the variance of PISA results in the 25 countries according to equation (4) we estimated six OLS regression models, separately for reading and mathematics, using the following equations:

(Model 1) $C_j^{15} = \alpha HDI_j + \varepsilon$

(Model 2) $C_j^{15} = \alpha HDI_j + \beta_1\ (HCI_j^{0-15}) + \beta_2\ (HCI_j^{0-15})^{\ 2} + \varepsilon$

(Model 3) $C_j^{15} = \alpha HDI_j + \beta_1\ (HCI_j^{0-3}) + \beta_2\ (HCI_j^{0-3})^{\ 2} + \varepsilon$

(Model 4) $C_j^{15} = \alpha HDI_j + \beta_1\ (HCI_j^{4-12}) + \beta_2\ (HCI_j^{4-12})^{\ 2} + \varepsilon$

[2] For PISA scores in reading and mathematics see Table A.2 in the Annex

(Model 5) $C_j^{15} = \alpha HDI_j + \beta_1 (HCI_j^{13-15}) + \beta_2 (HCI_j^{13-15})^2 + \varepsilon$

(Model 6) $C_j^{15} = \alpha HDI_j + \beta_1 (HCI_j^{0-3}) +$
$\beta_2 (HCI_j^{0-3})^2 \beta_1 \left(HCI_j^{4-12}\right) + \beta_2 \left(HCI_j^{4-12}\right)^2 +$
$\beta_1 \left(HCI_j^{13-15}\right) + \beta_2 \left(HCI_j^{13-15}\right)^2 + \varepsilon$

In model 1, we take into account only HDI as explanatory variable. In that way, we measure what is the variance of the results explained only by the variance of human development in the analysed countries. In subsequent five models, we take into account human capital investment in different ages. We follow the proposal of Heckman (2008), assuming that investments in different stages of the development of young people have different returns that should be considered differently.

In the model 2 the explanatory variable is the sum of total human capital investment between ages 0 and 15. In models 3-5 we add HCI in each selected age group as independent variable and finally, in model 6 we use all independent variables (HDI and HCI in age groups) together. In such manner, we can see, whether addition of each independent variable adds to the explanatory power of the model measured by the value of adjusted R-square.

Estimation results of models explaining results of PISA reading are summarised in table 2 (results for mathematics are not presented but conclusions are similar to reading). As it can be seen from the model 1, the HDI alone explains about 34,6% of variance in PISA reading score. When we add human capital investment variables for age groups 0-3 and 4-12 (models 2 and 3), it increases the value of R squared, but adjusted R square is decreased. Thus, HCI alone for these groups does not improve the explanatory power of the proposed model. Human capital investment in age group 13-15 improves the results – both value of R squared and adjusted R squared increase and the independent variable is statistically significant. Finally, when we use all variables (model 6), the explanatory power rises and the value of adjusted R squared is higher (compared to the model 1) by 26,7%. This means that the level of investment in human capital, mainly through public education consumption can improve educational outcomes, controlling for the level of economic and human development in the country. This effect is seen when we take into account human capital investment in subsequent stages of the life course from early childhood to lower-secondary education as well as we assume non-linear returns to human capital investment.

Results of models 5 and 6 show that public education consumption prior to PISA test (in age group 13-15) has a statistically significant impact on the test outcomes. The model

results indicate that the marginal increase of results in response to increased investment in education are declining with the level of spending, up to the maximum of around 0.8 annual level of average wage of a worker in age group 30-49. Beyond this point, the marginal returns can turn to be negative.

Tab. 1: OLS regression results: PISA reading

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
HDI	362,17*** (97,81)	354,60*** (107,21)	365,65*** (102,57)	360,02*** (104,65)	308,57*** (82,80)	271,19*** (84,260)
HCI_j^{0-15}		18,99 (51,18)				
$(HCI_j^{0-15})^2$		-3,16 (7,31)				
HCI_j^{0-3}			-92,72 (112,60)			-95,47 (95,03)
$(HCI_j^{0-3})^2$			58,86 (100,67)			50,66 (83,67)
HCI_j^{4-12}				22,368 (57,632)		-30,72 (48,56)
$(HCI_j^{4-12})^2$				-5,476 (12,341)		10,25 (10,49)
HCI_j^{13-15}					572,98*** (161,64)	820,81*** (189,13)
$(HCI_j^{13-15})^2$					-359,12*** (101,00)	-520,10*** (119,73)
Constant	177,55** (84,13)	157,55 (104,61)	201,50** (95,98)	158,26 (98,67)	7,604 (86,88)	-5,26 (91,44)
R2	0,373	0,386	0,412	0,384	0,609	0,726
Adj.R2	0,346	0,299	0,328	0,296	0,553	0,614

note: .01 - ***; .05 - **; .1 - *;, standard errors in parentheses, n=25 countries

Source: Authors‘ calculation

Conclusion

In the paper we propose an approach to quantify the impact of human capital investment on cognitive outcomes in the EU countries, using the National Transfer Accounts approach. Our results confirm that consumption leading to human capital development (education, health), particularly in early ages, has an impact on the level of cognitive skills, when controlling for the overall level of human development in the country. The model results indicate that the relationship between the cognitive skills and human capital investment takes a form of a quadratic function and investment in different stages of the life course has different outcome on the results. In the case of 15-year-olds, the way their public education consumption is

financed during the 3 years before the test performance seems to be most important in explaining the results.

Our results show importance of combining international research datasets in order to provide deeper insights into the interlinks between consumption and public expenditure and outcomes. The positive impact of increasing public education expenditure can be expected to certain overall level. While our results provide some quantitative indication on the role of investing in children development, the quality of spending is also important.

Our approach has certain limitations, that need to be highlighted. First, the age profiles are estimated at a certain point of time, that means that we assume that the level of education and health consumption by age does not change in time, which is a strong assumption. Second, in the model we focus on the part of the human capital investment, which is related to the monetary investment, mainly public. We don't take into account other characteristics, such as private non-monetary investment, related to the country differences in the amount of care and time spent by parents on the development of their children. In the future, the further extension of the analysis could be to include the value of time investment in children development using the estimated value of the National Time Transfer Accounts (NTTA). It will allow better capturing of private investment in the children development.

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