DISEI - Università degli Studi di Firenze

Working Papers - Economics

# The Importance of the Quality of Education: Some Determinants and its Effects on Earning Returns and Economic Growth

Lisa Grazzini

Working Paper N. 15/2016

DISEI, Università degli Studi di Firenze
Via delle Pandette 9, 50127 Firenze, Italia
www.disei.unifi.it

The findings, interpretations, and conclusions expressed in the working paper series are those of the authors alone. They do not represent the view of Dipartimento di Scienze per l'Economia e l'Impresa, Università degli Studi di Firenze

# The Importance of the Quality of Education: Some Determinants and its Effects on Earning Returns and Economic Growth

Lisa Grazzini*

Ottobre 2016

**Abstract**

The aim of this paper is to provide a selective overview on the role played by the quality of education versus the quantity of education. After a presentation of some possible effects of the quality of education on both individual earnings and growth, the paper analyses some important school inputs and institutional characteristics of the education system which have been examined in the economic literature and could affect education achievements.

Keywords: Human capital, Educational achievement, Earning returns, Economic growth.
JEL Classification: I21; I25; I26.

* Department of Economics and Management, University of Florence, Via delle Pandette 9, 50127 Florence, Italy. Tel. +39 055 2759562, e-mail: lisa.grazzini@unifi.it.

I wish to thank Alessandro Petretto for fruitful suggestions.

«*Skills enable people. They are capacities to function. Greater levels of skill foster social inclusion and promote economic and social mobility. They generate economic productivity and create social well-being. Skills give agency to people to shape their lives, to create new skills and to flourish*» *(OECD (2014) p.8).*

## 1. Introduction

Since education is one of the key issue for individual well-being and economic development, an important policy question faced by both academics and policy-makers is which are the best institutional features for a school system to improve the human capital of its students. This, thanks to the seminal papers by Schultz (1961), Becker (1964) and Mincer (1974), is now considered as the result of an investment in the acquisition of skills and knowledge by individuals. However, such an investment is also considered a dynamic process which occurs with different features at different ages, and which depends on the concomitant influence of several inputs as individual ability, family background, social environment, schools, and peers. All these inputs affect the capacity of an individual to accumulate human capital, and more specifically to succeed not only in education, but also in the labour market, and in all other aspects of life. In particular, such capacity rests on a multiplicity of skills which «are not traits set in stone at birth and determined solely by genes,» but which can be improved, and be more or less shapable depending on the age of the individual and the quality of the intervention (Kautz et al. (2014) p. 10).

The acquisition and the effects of human capital has of course a multidisciplinary nature and within the economic literature two strands of research have analysed the different steps that starting from inputs such as individual talent, family background, schools, etc. lead to the accumulation of human capital, i.e. the determinants of education, and consequently from the latter to desirable outcomes both for the individual and the population as a whole, i.e. the consequences of education. From a microeconomic point of view, these effects concern the labour market through income but also outside it through different channels concerning other aspects of life, and from a macroeconomic point of view, they refer not only to economic growth but also to positive externalities in many other social sectors.

Concerning this second strand of literature on the consequences of education, one important point recently stressed by many scholars concern the change of perspective from early works on the impact played by the quantity of education obtained by individuals to more recent studies on the importance played by the quality of their education in determining individual achievements and their impact on economic and social outcomes. Interestingly, such a change in perspective has not only interested the academic debate but also the policy arena. For example, in 2000, the second of the Millennium Development Goals was expressed in a quantitative way, i.e. «achieve universal primary education», while in 2015, the fourth of the Sustainable Development Goals has been stated in terms of quality of education, i.e. «ensure inclusive and quality education for all and promote lifelong learning».

As it will be pointed out in the paper, of course, it is more difficult to assess what students have learnt, and thus they actually know, with respect to how long they have been in school. However, nowadays, what students know is largely assessed thanks to a widespread tool: testing. In particular, many works surveyed in the present paper refer to the results of international tests which allow comparisons of school systems across different countries. Such international tests started in the 1960s to measure «a new concept –'general knowledge'- in an attempt to measure skills that are useful inside and outside of the classroom» (Kautz et al. (2014) p. 9). The results of such tests are now not any more just for researchers on education or policy-makers, they are at the heart of the public debate. Assessing students' performance is indeed crucial in order to understand which key inputs of the school system could be improved to boost students skill formation.[1]

Typically, however, scores on IQ tests and standardized achievement tests allow to measure cognitive skills which interact with other types of skills, noncognitive ones, the importance of which has been underlined by another recent literature started by Heckman and his coauthors. Contrary to cognitive skills,

[1] For example, in the 2010, the Obama Administration launched the 'Race to the Top' programme, a $4.4 billion initiative in favour of States that have proposed plans to reform schools with the aims (i) to adopt standards that allow students to succeed in college and the globalized workplace; (ii) to build data systems that measure students' outcome and growth, and provide information to teachers and principals on the ways they can improve their practices; (iii) to improve teacher and principal effectiveness by setting a link between student growth and teacher evaluations, tenure and promotions; and finally (iv) to turn around the lowest-performing schools. For more details, see http://www.rtt-apr.us. Similar initiatives have taken place also in other countries as the United Kingdom, Chile, Mexico, Israel, Australia, Portugal, and India (Fryer (2013)).

non-cognitive skills cannot be measured by such scores, and describe personal attributes such as «perseverance ('grit'), conscientiousness, self-control, trust, attentiveness, self-esteem and self-efficacy, resilience to adversity, openess to experience, emphaty, humility, tolerance of diverse opinions and the ability to engage productively in society» (Kautz et al. (2014) p. 9). Both types of skill are important for the development of individuals and are characterized by fundamental synergies. For example, the capacity to acquire cognitive skills is favoured by the development of non-cognitive skills, and both of them can be improved thanks to the quality of parenting, the social environment, and the school, a relationship which has been recently analysed by the first strand of economic literature cited above.

Given such recent interest on the role played by the quality of education, the present paper aims at focusing on it by referring to the two different lines of research mentioned at the beginning: The quality of education as a determinant for the future success of the individual and for a set of economic and social outcomes, and the quality of education as the result of a process which uses several inputs, among which this paper only concentrates the attention on those concerning the school.[2]

To pursue such an aim, the first part of the paper deals with the consequences of education. It presents a brief overview on the role played by the quality of education in shaping individuals, and thus benefiting them in and outside the labour market with also more general positive effects on economic growth. To appreciate the novelty of this recent literature, this part of the paper starts by presenting some hints on the early literature which, instead, has focused its attention on the role played by the quantity of education.

To complement our analysis, the second part of the paper deals with some main determinants of education. To analyse this issue from a theoretical point of view, the paper first provides a synthesis of a model by Cuhna and Heckman (2007) which allows to show how the skill formation process can be tackled through a multistage technology in order to take into account that childhood is made of multiple stages and some inputs, as parental investments and child environments, may have a higher productivity at some stages than at others, and some stages of the technology may have a higher productivity in producing some skills than other stages. Then, to provide some examples of works which belong to the large multidisciplinary empirical literature that has analysed the determinants of students' cognitive achievement measured by test scores outcomes, the paper presents a selective overview on some school inputs and institutional features of schools on which scholars have concentrated their attention and which could offer interesting insights for further reflections.

The plan of the paper is as follows. Section 2 briefly analyses the pecuniary and nonpecuniary effects of the quantity of education while Section 3 examines the role played by the quality of education both from a microeconomic and a macroeconomic point of view. Section 4 sketches the model by Cuhna and Heckman (2007) on the production of children skills, and Section 5 point out some important school inputs and institutional features of the education system that have been analysed in the empirical literature, and that may affect student achievements. Section 6 contains some concluding remarks.

## 2. Pecuniary and nonpecuniary benefits of the quantity of education

Schooling and human capital investments have been and are central in the economic and policy debates on how to improve the individual earning capabilities and the growth rate of countries both in the developed and the developing world. Nowadays, such microeconomic and macroeconomic effects of education have been largely analysed in the economic literature: while the early works were more concerned with the role played by the quantity of education, e.g. school attainments, [3] the more recent studies have stressed the importance that the quality of education can have in shaping individuals, and thus benefiting them both in and outside the labour market with also more general positive effects on economic growth.

Even if the aim of this work is to concentrate the attention on the benefits arising from the quality of education, it is useful first to recall very briefly some important results concerning the role played by the quantity of education both in pecuniary and nonpecuniary terms, not only from a private perspective but also from a social one.

[2] However, even restricting our focus on school policies, we need to be aware, as pointed out by Hanushek and Rivkin (2006), of a main difficulty faced by research due to the fact that the different effects determining students' outcome are not easily distinguishable given that this depends on many inter-linked decisions taken by different actors, namely parents, teachers, school administrators, and policy-makers.

[3] For a survey on the relationship between education and growth, but also on the relationship between democracy and growth, and education and democracy, see, for example, Grazzini (2009).

## 2.1. Pecuniary benefits

From a microeconomic point of view, much of the economic literature has concentrated the attention on the value of education as an investment in human capital, and much of the theoretical[4] and the empirical[5] work have focused on the pecuniary returns to such investment, reaching a large consensus on the result that, on average, higher wages correspond to higher levels of education.[6] However, as stressed by Dickson and Harmon (2011, p. 1118), «estimates of [the return to education investment] vary significantly, depending on the data sets used, the assumptions made and the estimation techniques.» In particular, one of the main difficulties in estimating a causal effect of education on earnings is due to the fact that it is not easy to know whether the higher earnings observed for individuals with higher level of education are caused by their higher level of schooling or whether the individuals who have greater earning potential have chosen to obtain more education. Another complication in cross-country analyses comes from the comparability problems that arise when a large set of countries is studied over a long period. For example, to face this problem, recently Montenegro and Patrinos (2014) have made an effort in compiling comparable estimates by using the same specification, estimation procedure, and similar data for a large set of countries.[7] One of their most interesting result shows a sharp decline in returns to schooling since the 1980s (by 3.5 percentage points over a 30 year period), in partly due to the expansion in schooling (more than 3 years in the same period).

From a macroeconomic point of view, the main focus has been instead concentrated on the relationship between education and economic growth. This issue has been largely analysed by the theoretical growth literature which predicts a positive role for human capital in affecting growth. Human capital can stimulate growth by increasing or complementing the existing factors of production (Lucas (1988)), it can accelerate growth through innovations, i.e. new knowledge on new products and technologies (Romer (1990)), or through the imitation and adoption of new technologies, i.e. through the ability of more educated workers to understand and process new information, and thus to implement frontier technologies devised by other countries[8] (Nelson e Phelps (1966)). From an empirical point of view, the evidence for such an effect is however controversial,[9] especially on whether it is the stock of human capital or the change in the stock of human capital that it is the more decisive engine for economic growth.[10] In large part, this mixed empirical

[4] However, in the theoretical literature, there is no consensus on the causes of such result. For example, education could increase the labour productivity of the workers (Becker (1964)), or in an adverse selection framework, it could be used as a signaling device by workers to signal their labour productivity which is not perfectly observable by employers (Spence (1973)), or it could be used by employers as a screening device to select higher productivity workers who also have higher education levels (Stiglitz (1975)). For a discussion on these different approaches, see, for example, Checchi (2006).

[5] See the seminal contribution by Mincer (1974) and, more recently, Harmon et al. (2003). See Card (1999, 2001) for a review which enlights different types of econometric problems arising when estimating the causal relationship between schooling and labour market earnings by also focusing on studies that use institutional aspects of the schooling system as exogenous determinants of education outcomes.

[6] See, however, the strand of literature on overeducation, i.e. on a mismatch between individuals' education and educational requirement of job or occupations and the main theoretical explanations for such a phenomenon (e.g. human capital, job competition, assignment and search models). For a survey with special attention to measurement problems and policy implications see, for example, Leuven and Oosterbeek (2011).

[7] See Trostel et al. (2002) for a paper that addresses the comparability problems across countries by using comparable microdata to estimate the economic return to schooling, and that shows a very large cross-country variation in the return to schooling for which ready explanation defies. See also Breton (2013) for a recent analysis that also examines the implications for economic growth and public policies.

[8] In this sense, the educational investment would have a positive effect not only on the productivity of the more educated workers but also on that of their colleagues.

[9] For useful surveys, see Aghion and Howitt (1998), Stevens and Weale (2004), Gradstein et al. (2005), Hanushek and Woessmann (2008), and Sauer and Zagler (2012).

[10] Some important references are, for example, Benhabib and Spiegel (1994), Barro and Sala-i-Martin (1995), Temple (1999), Topel (1999), Krueger and Lindahl (2001), Vandenbussche et al. (2006), Sunde and Vischer (2015)). For a discussion on several difficulties that arise in estimating the relationship between education and growth see, for example, Wößmann (2003) and Krueger and Lindahl (2001). The latter also discusses possible omitted variable bias in cross country analyses due to the fact that, for instance, countries that enhance their educational systems are likely to simultaneously vary other policies which positively affect growth. For an analysis of the influence of education on growth at a regional level, see Gennaioli et al. (2013) who show that regional development is affected not only by workers' education, but also by entrepreneurs/managers' education, and externalities. See, instead, Bils and Klenow (2000) for a paper that stress the fact that there could be an issue of reverse causality, i.e. higher economic growth could cause additional demand for education (e.g. growth could be previewed, and this could reduce the discount rate, increasing the demand for education).

evidence is due to measurement problems. As pointed out by Hanushek and Wößmann (2011), the standard method to estimate how education can affect economic growth is to estimate cross-country growth regressions where average annual growth in GDP per capita over several decades is a function of measures of schooling and other variables considered important for economic growth. Some drawbacks behind the most commonly used measure for schooling in such works, i.e. average years of schooling in the working-age population, will be discussed below in section 3.2.

## 2.2. Nonpecuniary benefits

Returns to education other than the private financial ones have been also analysed in the economic literature. Indeed, if education is not treated as a black box where «individuals enter, something happens, and productivity (usually defined in terms of one-dimensional skill) increases» (Oreopoulos and Salvanes (2011) p. 159), one needs to analyse whether education might affect individual well-being not only on the labour market through income, but also outside the labour market through other channels. These may entail additional non-monetary private benefits so that the whole returns from education may be higher than what predicted by the traditional Mincer estimates. For example, schooling is strongly and positively correlated to two sets of skills such as critical thinking which are useful for individuals to process new problems and make better choices, and social skills which may help individuals in working in groups (Oreopoulos and Salvanes (2011)). Accordingly, an improvement in these types of skill may generate nonmonetary returns outside the labour market because the more educated individuals are able to get more done with the same amount of time than the less educated, i.e. the productive efficiency approach, or because the more educated select a different mix of inputs to produce a given commodity than the less educated, i.e. the allocative efficiency approach (Grossman (2006)). Some key nonpecuniary benefits from education on which attention has been concentrated are, for example, those on own health and children health, fertility, saving rates, children development and their socioeconomic success (Dickson and Harmon (2011), Oreopoulos and Salvanes (2011)). Further, schooling may also affect preferences by making individuals more patient, more determined, and less likely to take on risky behavior, as teen fertility, criminal activity, and smoking which negatively correlate with years of completed schooling (see Oreopoulos and Salvanes (2011)).[11]

Finally, one of the most important justification for public involvement in the market for education is the existence of a market failure due to positive externalities that may be related to schooling. Of course, if such positive externalities are sufficiently large, then the social return can be higher than the private return to the investment in education. Several possible external social benefits of education have been investigated as, for example, in terms of technological progress, better law enforceability, more stable democracy, social cohesion, political participation, lower criminality, better health status of the population, improvements in the human capital of future generations, etc..[12] In particular, the link between educational attainment and several civic behaviours have been studied by both the political science and the economic literature which report strong correlations between such variables. To identify causal effects is however a difficult task, as stressed for example by Dee (2004, p. 1698) due to the fact that the correlation between schooling attainment and various civic behaviours could «be quite misleading since both schooling and civic outcomes are simultaneously influenced by a wide variety of inherently unobservable traits specific to individuals and the families and communities in which they were reared». By using instrumental variables that generate exogenous changes in the levels of individual education, Dee (2004) is however able to identify causal effects showing that education augments in particular voter participation, free speech and civic knowledge.

[11] As it stressed, for example, by Oreopoulos and Salvanes (2011), research on the effects of schooling is difficult in general because a higher level of education may be correlated with other factors, e.g. family background and skills that individuals already possess, and thus it is not easy to separate the effect of schooling alone when analysing its causal effect. Moreover, in studying the nonpecuniary effects of education, it is difficult to disentangle their effects taken alone from the effects due to the fact that more schooling gives rise to more income which also have an influence on people's lives. See such paper, for a discussion on these points, and for a presentation of some approaches to estimating nonmonetary returns to education which are more satisfying for causal inference.

[12] For a recent survey on the effects of education on crime, health and citizenship, see Lochner (2011).

## 3. The importance of the quality of education

The analyses briefly sketched in the previous section on the relationship between quantity of education and both individual and social outcomes have been, however, recently criticized because they miss to take into account the different quality levels implied in the same amount of education. In particular, drawbacks related to different measures of school attainments have been discussed both by using a microeconomic and a macroeconomic point of view that we now analyse in the following two subsections.

### 3.1. Microeconomic viewpoint

From a microeconomic point of view, previous analyses on the link between quantity of education and individual earnings have disregarded two major issues. First, as stressed by the literature on education production functions, empirical estimates should take into account the importance of cognitive skills for individual earnings. Second, also a variety of noncognitive skills, as for example, honesty, persistence, communication skills, and team working abilities, should be taken into account given that they can affect human capital, and accordingly also individual earning capacities. In the following section, a synthesis of a recent model by Cuhna and Heckman (2007) will be provided allowing to analyse how both cognitive and noncognitive abilities are produced by using as inputs child environments, parental investments, and genes.

Cognitive abilities are achievable not only through formal schooling but also through other sources, as families, peers, culture, abilities, and so forth. In empirical analyses, all these sources of cognitive skills are usually proxied by international test scores which, however, at an individual level, are affected not only by cognitive inputs, but also by noncognitive, and environmental inputs (Cuhna and Heckman (2007)), and at a macro level, they also depend on variations on school quality both across countries and within them.[13] As surveyed by Hanushek and Wößmann (2008), higher school quality measured by higher achievements on standardized tests are closely associated to individual earning advantages in a variety of papers which, however, have most generally considered the case of young workers in the United States.[14] More recently, cross-section analyses have been performed. For example, an estimation of the earnings returns to cognitive skills across 23 countries has been recently conducted by Hanushek et al. (2015) on the basis of the data available from the Programme for the International Assessment of Adult Competencies conducted by the OECD in 2011-2012. A first result shows that estimates taking into account early-career earnings underestimate the lifetime returns to cognitive skills given that, for example, workers with higher lifetime earnings have usually steeper earnings growth, and the revelation of individual skills may take some time. A second result points out a high cross-country variety in returns to skill: Six countries indicate returns to skill above 21% (U.S., Ireland, Germany, Spain, U.K., and Korea); nine countries indicate returns to skill between 15% and 20% (Australia, Canada, Poland, Japan, Netherlands, Slovak Republic, Austria, Estonia, and France); and eight countries have, instead, returns to skill below 15% (Belgium, Finland, Cyprus, Denmark, Italy, Norway, Czech Republic, and Sweden). A final result which is worth noting shows that returns to skill are lower in those countries with a stricter employment protection legislation, higher union density, and larger public sectors.

A second important determinant of individual earnings other than cognitive abilities has been stressed in particular by James Heckman and co-authors in various papers, and it is identified in noncognitive skills. In general, the importance of noncognitive abilities for success in life is suggested by common sense, but also by the sociology and the psycology literature. More recently, the economic literature has also pointed out how noncognitive abilities may be fundamental in shaping individual performances on the labour market. Indeed, achievement tests are not able to capture in an adequate way noncognitive skills, such as self-control, self-esteem, perseverance, team working abilities, openess to experience, communication skills, etc. which, however, are valued not only in the labour market but also in society at large. As reviewed by Kautz et al. (2014),[15] a growing body of empirical analyses stresses the importance of noncognitive abilities not only on educational achievements and labour market success, but also on health and criminality. In particular, a paper by Heckman et al. (2006) shows that noncognitive skills -motivation, persistence, and self-esteem- increase wages through two effects. Noncognitive abilities have a direct positive effect on wages through an

[13] Of course, test may also suffer from several other problems as the reliability of questions or the impact of test taking conditions on scores (Hanushek and Wößmann (2008)).

[14] Notice that a part of the return to cognitive abilities comes through going farther in school.

[15] See, in particular, Heckman et al. (2006), and also the cited references in Kautz et al. (2014).

increase in market productivity, and they also have an indirect positive effect on wages through schooling and work experience.

The importance on noncognitive skills is also at the basis of a recent paper by Chetty et al. (2011) that shows that the quality of the classroom a student is assigned at the kindergarten, in terms of class size, teacher and peer characteristics, matters for both test scores and future earnings. According to this analysis, noncognitive skills built at early childhood may have returns in the labour market. More precisely, class quality has a significant impact on socioemotional abilities, such as effort, initiative, and lack of disruptive behaviour, which are highly correlated with future earnings.

In sum, the recent microeconomic literature stresses the importance of both cognitive and noncognitive skills as important predictors of individual educational attainments, and success in the labour market. In the following subsection, we briefly refer to some recent papers that also finds a positive impact of the quality of education, at an aggregate level, on growth.

### 3.2. Macroeconomic viewpoint

From a macroeconomic point of view, the cross-section analyses described in the previous section on the effects of the quantity of education have been criticized mainly because a quantitative measure of schooling, such as average years of schooling, has at least two main drawbacks. First, using years of schooling as a proxy implies that a year of schooling has the same effect on students' knowledge and skills irrespective of the country, i.e. it does not take into account that the quality of educational systems is different across countries. Second, such a proxy does not take into account that education outcomes are affected not only by formal schooling, but also by the quality of nonschool factors, as for example family, peers, and culture (Hanushek and Wößmann (2012)). Accordingly, as all these factors seem to play an important role in affecting workers' human capital, and thus growth, they should be taken into account by empirical economic analyses. To pursue such a task, a way is to consider the results of the international tests to measure the education abilities of students.

Since the mid-1960s, many international tests, such as the Progress in International Reading Literacy Study (PIRLS) which tests reading performance at primary school, the Trends in International Mathematics and Science Study (TIMSS) which tests math and science performance of eight-graders, and the Programme for International Student Assessment (PISA) which tests math, science, and reading performance of 15-year-olds,[16] have been performed by international agencies in order to measure students' cognitive skills in mathematics, science, and other subjects.[17] Countries' differences are enormous: among OECD countries, the variation in results is substantial, but they become dramatic between developing and developed countries. For example, the PISA 2012 results in mathematics show an OECD average score of 494, and a mean score of 613 of the top performer Shanghai-China, followed by Singapore (573), and Hong Kong-China (561), while at the bottom of the ranking, Peru obtains the lowest score 368, preceded by Indonesia (375), and Qatar (376). Large differences also exist among countries with respect to the share of students who are top performers.[18] Across OECD countries, still in mathematics, on average, 13% of students are top performers, but such a share is 55% in Shanghai-China and 40% in Singapore while it is only 0.3% in Argentina, Colombia, and Indonesia.

On the basis of such tests, Hanushek and Kimko (2000) find a statistically and economically significant positive effect of cognitive abilities on growth for the period 1960-1990 which is larger than the association between quantity of education and economic growth. Several further papers recently surveyed by Hanushek and Wößmann (2011) confirm the important effect of the quality of education for growth. Hanushek and Wößmann (2008), in particular, provides some evidence which allows to point out three main results when cognitive skills are measured by an average of the mathematics and science scores on international students achievement tests. First, they show that test scores have a statistically significant impact on growth in the period 1960-2000 for a sample of fifty countries. Precisely, «test scores that are larger by one standard

[16] Recently, PISA 2012 has introduced some tests to capture also noncognitive skills as openness, locus of control, and motivation.

[17] Such tests contain questions not only on school curricula but also on real-world phenomena, and they are conducted by international agencies such as the International Association for the Evaluation of Educational Achievement (IEA) and the Organization for Economic Cooperation and Development (OECD).

[18] Top performers in mathematics correspond to Level 5 or 6, i.e. «they can develop and work with models for complex situations, and work strategically using broad, well developed thinking and reasoning skills» (OECD (2014)).

deviation (measured at the student level across all OECD countries in PISA) are associated with an average annual growth rate in GDP per capita that is two percentage points higher over the whole forty-year period.»[19] A second interesting result shows that the distribution of education also plays an important role for growth. Specifically, both the share of absolutely top performers and basic education for all have independent positive effects on growth. Finally, a third result shows that the positive effect of quality of education on growth is robust to the inclusion of some institutional features of the economy recently stressed by the economic literature as important determinants of growth, such as the openess of the economy to international trade and the security of property rights (Acemoglu (2009), Acemoglu et al. (2014)). In particular, Hanushek and Wößmann show that not only both educational quality and openness to international trade have significant positive effects on economic growth, but that there is also a significant positive interaction, so that good cognitive abilities and qualified institutions seem to strengthen each other in promoting economic growth. Specifically, the impact of the quality of education on growth may differ depending on the economic institutions of a country, and it seems larger in those countries with a better productive institutional set-up.[20]

Finally, it is interesting to notice that, also when the quality of human capital is taken into account, both the levels and the variations of it can be relevant for growth. For example, the importance of the quality of human capital for growth has been underlined by a paper by Sunde and Vischer (2015) which shows that both the initial levels and the changes in human capital quality matter. Their results are qualitatively very similar when the quality of human capital, measured as the teacher/student ratio, is used instead of the quantity of human capital, measured in terms of years of schooling, thus corroborating the theoretical findings which point out the two distinct channels through which human capital can affect growth.

## 4. The production of skills

The previous section has stressed how both cognitive and noncognitive abilities are important in shaping the socioeconomic success of individuals. However, the literature has not yet reached a consensus view on which inputs are more important in shaping children and future adults skills, as for example with reference to genetics, family background, and school environment. A recent model by Cuhna and Heckman (2007) sheds some light on this issue, proposing to analyse the skill formation process by means of a multistage technology. In this setting, childhood is not treated as a single period, but multiple stages of childhood are allowed in order to take into account that qualitatively different inputs, as parental investments, and child environments, can be used at different stages, and that also different technologies can be used at different stages of child development. In particular, different periods in the life cycle of a child corresponds to different stages. Inputs at each stage produce outputs in terms of skills at the next stage. However, some inputs may have a higher productivity at some stages than at others, and some stages of the technology may have a higher productivity in producing some skills than other stages.

Cuhna and Heckman consider an overlapping generations model where each household consists of an adult parent and her child. Every individual lives for $2T$ periods. During the first $T$ periods, the individual is a child and from age $T+1$ to $2T$ is an adult and is the parent of a child. Each year there are an equal and large number of individuals of every age $t \in \{1,2,\dots,2T\}$. Parents share the same preferences, supply labour in an inelastic way, and are altruistic towards their children. Suppose that every child is born with initial condition $\theta_1$, but her skills evolve over time. When the child is $t$ years old, the technology of production of skill is as follows

$$\theta_{t+1} = f_t(h, \theta_t, I_t) \quad t = 1,2,\dots,T, \tag{1}$$

where $\theta_{t+1}$ denotes a vector of skills at stage $t+1$, $h$ represents parental characteristics, e.g. educational level and emotional skills, $\theta_t$ denotes the vector of skill stocks, and $I_t$ represents the investments made by the parent in child skills when the child is $t$ years old. Further, the function $f_t$ is assumed strictly increasing and strictly concave in $I_t$, and twice continuously differentiable in all of its arguments.

[19] Hanushek and Wößmann (2008) p. 638.

[20] Murphy et al. (1991) had already stressed the fact that economic growth is also affected by the allocation of talent between rent-seeking and entrepreneurship, showing that, for example, countries with relatively more law students grow more slowly than those countries with more engineering students.

This technology allows for two important effects. The first one is named *self-productivity* and describes the fact that the skills produced at one stage increase the skills acquired at later stages, or in other words skills obtained at a certain time of the child life cycle persist into future periods so that they are "self-reinforcing and cross fertilizing." Such an effect arises when

$$\frac{\partial f_t(h, \theta_t, I_t)}{\partial \theta_t} > 0$$

The second effect is termed *dynamic complementarity* and describes the fact that skills acquired at every stage increase the productivity of investment at subsequent stages. It arises when

$$\frac{\partial^2 f_t(h, \theta_t, I_t)}{\partial \theta_t \partial I_t} > 0$$

Accordingly, for children with a higher vector of skills $\theta_t$, the returns to educational investments are larger at later stages of the life cycle of the child. In the words by Cuhna and Heckman (2007, p. 35), «[t]ogether, dynamic complementarity and self-productivity produce multiplier affects which are the mechanisms through which skills beget skills and abilities beget abilities.»

By substituting in (1) for $\theta_t, \theta_{t-1}, \ldots$, repeatedly, the stock of skill at $t+1$, can be rewritten as

$$\theta_{t+1} = m_t(h, \theta_1, I_1, \ldots, I_t) \quad t = 1,2, \ldots, T. \tag{2}$$

This technology also allows to describe some particular periods that occur during the child life cycle. A *critical period* for a certain skill occurs if one stage alone is effective in generating such a skill. Thus, $t^*$is a critical period for $\theta_{t+1}$ if

$$\frac{\partial \theta_{t+1}}{\partial I_s} = \frac{\partial m_t(h, \theta_1, I_1, \ldots, I_t)}{\partial I_s} \equiv 0 \ \ \forall h, \theta_1, I_1, \ldots, I_t, s \neq t^*,$$

but

$$\frac{\partial \theta_{t+1}}{\partial I_{t^*}} = \frac{\partial m_t(h, \theta_1, I_1, \ldots, I_t)}{\partial I_{t^*}} > 0 \ \ for\ some\ h, \theta_1, I_1, \ldots, I_t.$$

In words, investments in $\theta_{t+1}$ are effective at year $t^*$ but not in any other year $s \neq t^*$.

*Sensitive periods* for acquiring certain skills are those stages of the child life cycle that are more effective in producing such skills. Thus, $t^*$is a sensitive period for $\theta_{t+1}$ if

$$\left.\frac{\partial \theta_{t+1}}{\partial I_s}\right|_{h=\bar{h}, \theta_1=\theta, I_1=i_1, \ldots, I_t=i_t} < \left.\frac{\partial \theta_{t+1}}{\partial I_{t^*}}\right|_{h=\bar{h}, \theta_1=\theta, I_1=i_1, \ldots, I_t=i_t}$$

This condition states that if, at the same level of inputs, investment is more productive in period $t^*$ than in another period $s, s \neq t^*$, then period $t^*$ is a sensitive period with respect to period $s$.

To simplify, let us now consider that $T = 2$. Thus, the stock of skills of an adult, $h' = \theta_3$, arises as

$$h' = m_2(h, \theta_1, I_1, I_2). \tag{3}$$

In words, the adult stock of skills is a function of the characteristics of her parent, $h$, initial conditions, $\theta_1$, and investments during childhood made in periods 1 and 2, $I_1$ and $I_2$. More specifically, by using a CES function to specify the investment process, the function (3) can be rewritten as follows

$$h' = m_2(h, \theta_1, [\gamma(I_1)^{\phi} + (1-\gamma)(I_2)^{\phi}]^{\frac{1}{\phi}}), \tag{4}$$

for $\phi \leq 1$ and $0 \leq \gamma \leq 1$. Notice that $\phi$ describes the degree of complementarity or substitutability between $I_1$ and $I_2$, i.e. between early and late investment in producing skills; $\gamma$ is a skill multiplier that describes the productivity of early investment $I_1$ in increasing $h'$ directly and in augmenting the productivity of late investment, $I_2$, by boosting $\theta_2$.

Let us now analyse the optimal decision of the parent in terms of consumption and investments at different periods, and a bequest for the child, $b' \gtreqless 0$. Her budget constraint obtains as

$$c_1 + I_1 + \frac{c_2 + I_2}{1+r} + \frac{b\prime}{(1+r)^2} = wh + \frac{wh}{1+r} + b, \tag{5}$$

where $c_1$ and $c_2$ denote the household consumption in the first and second period of the life cycle of the child, respectively, $r$ represents the interest rate, $w$ denotes the wage rate, and $b$ represents the bequest received by the parent when she becomes adult. The utility function is denoted by $u(.)$, and the recursive formulation of the parent's problem is given by

$$V(h, b, \theta_1) = max\{u(c_1) + \beta u(c_2) + \beta^2 \delta E[V(h', b', \theta_1')]\}. \tag{6}$$

Thus, the parent problem is to maximize (6) subject to the budget constraint (5) and technology (4).

The solution to this problem depends on the values of $\phi$ and $\gamma$. In particular, if $\phi = 1$, early and late investment, $I_1$ and $I_2$, are perfect CES substitutes. By using one unit of $I_1$, the amount of human capital produced is equal to $\gamma$, and by using $(1 + r)$ of $I_2$, the amount of human capital produced is $(1 + r)(1 - \gamma)$. On the one hand, a higher value of $\gamma$ will make more productive to allocate resources in early investment. On the other hand, a higher value of $r$ will drive the parent towards more late investment. Accordingly, the two parameters affect the parent's choice in opposite directions, and an early investment is optimal if $\gamma > (1 + r)(1 - \gamma)$.

If, instead, $\phi \to -\infty$, the opposite Leontief case arises, and the optimal strategy for the parent is to choose $I_1 = I_2$. Thus, as Cuhna and Heckman (2007, p. 37) point out «[i]t is essential to invest early to get satisfactory adult outcomes. But it is also essential to invest late to harvest the fruits of the early investment.» Notice that this technology allows to explain the empirical result, for disadvantaged adolescents with low $h$, $I_1$ and $\theta_2$, on the low returns to education in the adolescent period and, on the contrary, the high returns to education in the early period.

In sum, when the degree of complementarity is high, if the parent chooses a high early investment, she should also choose a high level of late investment. When, instead, the degree of complementarity reduces, and the value of $\gamma$ increases, the parent should choose a higher early investment. The empirical analyses by the same authors allow to get more insights on the interaction between cognitive and noncognitive skills and, in particular, on the role played by complementarity, self-productivity and sensitive periods when parental investments are more productive. Specifically, they provide evidence of higher substitutability of early and late investment in creating noncognitive skills and lower substitutability in creating cognitive skills. Higher stocks of both types of skill augments the productivity of subsequent investments made by parents or the public sector and, further, a beneficial interaction may arise between them. Higher levels of cognitive skills favour the self-productivity of noncognitive skills and viceversa. The productivity of the two types of skill also depends on the child development stage: the productivity of parental investment in cognitive skills is higher in early stages and decreases in later stages while, for noncognitive skills, the productivity of parental investment is higher at later stages.

The previous analysis, from a normative viewpoint, offers thus interesting cues for designing public policies that can be effective in favouring the child accumulation of human capital. Their capacity to purse such aim depends indeed on the nature of the technology, i.e. the degree of complementarity between early and late investments, and on whether such policies are anticipated or not by the parents. In the case of early investments to promote children's skill accumulation there is no trade-off between efficiency and equity because both criteria suggest interventions in favour of children from disadvantaged backgrounds. For late investments, the type of technology is crucial because when there is substitutability between early and late investments, scarce early investments can be compensated by late investments while this is not the case when there is complementarity. However, the optimal intervention also depends on whether public policies are anticipated or not by the parents. If, for example, the degree of complementarity is high, and a policy providing subsidies to late investments is not anticipated, it will be ineffective for those children coming

from disadvantages families where poor early investments have been already made. If, instead, the policy is anticipated, for example, because it is announced largely in advance (e.g. before the child's birth), the parent may alter early and late investments in order for the child to benefit from the subsidy to late investment.

## 5. Some important inputs affecting education

The theoretical analysis in the previous section has shown that the child development should be considered a cumulative process that relies on individual talent, family's history and school inputs. From an empirical standpoint many difficulties arise when the determinants of cognitive achievements are estimated in a consistent way with respect to such theoretical approach. As pointed out by Todd and Wolpin (2003), there exists a very large and multidisciplinary empirical literature that examines the determinants of particular students' cognitive achievement and, for example, a branch of it, the education production function literature, tries to understand the productivity relationship between different inputs and usually test scores outcomes.[21]

Empirical studies, however, do not reach a consensus on which inputs are more important in increasing students' achievement (even when using the same data sets). Usually this is due to the fact that production function parameters are estimated by using nonexperimental studies[22] and two major difficulties in estimation arise from problems with missing data and a wide variety of empirical specifications. Inputs are generally imprecisely measured because of missing data on both past and present family and school inputs and children endowments. For example, data sets obtained by schools usually contain information on current schooling inputs and limited information on family inputs. To counter such problem, researchers sometimes develop estimators that allow for the presence of omitted variables or prefer to use one or more proxy variables to reduce omitted variables bias relative to excluding them.[23] However it is not an easy task to understand which strategy has to be preferred given that a comparison between two unknown biases is involved. In this respect, Todd and Wolpin (2003) suggest caution in introducing proxy variables because their inclusion can make estimates difficult to interpret. [24] Of course, in estimating this type of education production function, what one would like to estimate is the human capital of individuals which is, however, not directly observed. For this reason, the use of test scores on mathematics, science, and reading, has been widely accepted as proxy of cognitive skills. Indeed, it should be stressed that test scores can capture the total outcome of education, being its source the family, the school, and individual ability.

Being aware of such difficulties, among the possible inputs that may affect educational achievements, we now provide just a brief and selective overview of some school inputs and institutional characteristics of the education system which have been analysed in the literature. [25] This means that other important determinants in the students' educational process, as student characteristics and family background will not treated in the present work. [26] In this respect, we just mention that parents' education and, more generally, their socio-economic status have long been recognized as important determinants in the students' educational process. For example, for the case of the European countries, education appears to be unequally distributed and highly correlated with family background, and accordingly contributing to a subsequent inequality in income distribution (Braga et al. (2013)). Estimates of international education production functions have confirmed such concern by showing a significant association of students' achievement with many measures of student and family background. Of course, the effect of family background on academic achievement also provides important information on equality of opportunity of students coming from different background, and thus on

[21] See also the recent survey by Hanushek and Wößmann (2014).

[22] These are based on observational data and it is assumed that the inputs into the education production process are chosen by parents and schools. Alternatively, in experimental studies some inputs are not chosen by parents or schools but by random assignment. As stressed by Todd and Wolpin (2003), the two types of studies estimate different parameters and thus we should not expect that their results match.

[23] For a discussion on the pro and cons of different strategies we refer, for example, to the papers by Todd and Wolpin (2003, 2007) and Krueger (1999).

[24] For a discussion on econometric issues regarding the estimation of an education production function across countries, see, for example, Hanushek and Wößmann (2011).

[25] For a survey on the relationship between educational policies and the quantity of education, see Checchi et al. (2013). See Braga et al. (2013) for an analysis on how different institutional characteristics of European education systems may affect both the mean and the distribution of educational attainments measured by the number of actual years of education completed.

[26] For a recent survey on the association between family background and educational attainment measured in a quantitative way, i.e. by years of schooling, see Björklund and Salvanes (2011).

intergenerational mobility of a society. Given that each individual does not choose his/her family background, and hence cannot be held responsible for it from a normative point of view, when the impact of the family background on the students' achievement is strong, educational opportunities are less equally distributed.[27]

We now turn to a description of some school inputs and institutional features of the education system that the economic literature has studied in order to understand which are the main determinants of the quality of education.

## 5.1. School resources

To analyse the impact of school resources on students' achievement, the economic literature has usually considered proxy variables as, for example, expenditure per-student, class size, and teacher characteristics. In what follows, we just describe the effects of class size and teacher characteristics.

### 5.1.1. Class size

Although conventional wisdom would suggest that smaller classes should have a positive impact on student achievement, the empirical literature on the subject has not consistently confirmed it, leading to the so-called 'class size puzzle', i.e. «the failure of the empirical literature to consistently find the expected relationship between class size and student achievement» (Bosworth (2014) p. 142).[28] This issue has been analysed both at a national and at an international level with mixed results.[29]

At a national level, for example, a recent paper by Fredriksson et al. (2013) evaluates the long-term effects of class size in primary school in Sweden, showing that smaller classes have positive effects on both cognitive and noncognitive skills. Similarly, by analysing the case of the public school system in the North Carolina, Bosworth (2014) shows that the class size effect may be different according to the students' characteristics. For instance, class size reductions may be more beneficial for low-income students, even if the magnitude of the effect of class size on both average achievement and achievement gaps tends to be quite small. Some other relevant studies are those based on the Tennessee's Project Student/Teacher Achievement Ratio (STAR) which was an experiment in which 11,571 students and their teachers were randomly assigned to small classes (15 students on average) and large classes (22 students on average) during the first four years of school. For example, Krueger (2003) estimates that the internal rate of return from reducing class size from 22 to 15 students is about 6%. More recently, Chetty et al. (2011) finds that students in small classes are significantly more likely to be enrolled in college at age 20, and exhibit improvements on a summary index of other outcomes (e.g. home ownership, marital status, etc.). It, however, does not find that smaller classes have a significant effect on earnings at age 27.

Finally, at an international level, Hanushek and Wößmann (2011) point out that international evidence, both across and within countries, on the effect of class size on academic achievement shows no strong impacts in most countries, even if such effect seems to be larger in classes with low teacher quality. According to their analysis, it is not a surprise to find, at an international level, no relationship between the cumulative spending per student from age 6 to 15 and the average math achievement of 15-year-olds on the 2003 Pisa test given that student-teacher is the most important determinant of overall spending in education.

[27] For an example of this type of analysis, see Schuetz et al. (2008) who compare the association between students' achievement and family background across 54 countries where, as in most works, the social, and economic background of the family is measured by the number of books in the students' home. Their results show that the estimated family background effect is very different across countries: England, Scotland, Hungary, and Germany are the countries with the highest impact of socio-economic differences on achievement, on the opposite, France, Canada, Portugal, and Belgium Flemish are the countries with the least impact while Norway, Greece, and Italy result in an intermediate position.

[28] This could be also due to the fact that estimating the impact of class size reduction on educational achievement is a difficult task because such relationship could be affected by several effects such as the non-random assignment of students to classes, peer characteristics, and teacher strategy.

[29] See Krueger (2003), for a discussion on the literature and for references on papers finding a positive relationship between class size and student outcomes and papers not finding such a relationship.

### 5.1.2. Teacher characteristics

Public discussion tends to focus on the key role of teaching quality for promoting student achievement: Parents, teachers, and policy makers agree on the crucial role played by teachers in determining school quality. But which teacher characteristics may improve school quality is still a highly debated issue, as the following issue on how incentives should be designed in order to improve them (for example, individual or school rewards). Further, teacher quality is not usually common to all students: Evidence seems to suggest that some teachers may be more effective with some students than with others (Hanushek and Rivkin (2006)). More generally, however, teacher quality is difficult to observe, and indirect evidence needs to be used by researchers who have to face further difficulties.[30] For example, education is usually publicly provided so that teacher hiring decisions are not necessarily linked to expected performance, and teacher supply decisions may be also motivated by nonpecuniary factors such as the intrinsic rewards from teaching and the "family friendly" nature of teacher employment (Hanushek and Rivkin (2006)).

Most of the recent research has concentrated the attention on the link between teachers and student outcomes.[31] Such an outcome-based perspective is based on the idea that «a good teacher is simply one who consistenly gets higher achievement from students (after controlling for other determinants of student achievement such as family influences or prior teachers)» (Hanushek and Rivkin (2012) p. 132). This method, commonly called value-added (VA) analysis, tries to evaluate teacher effectiveness in improving students' test scores. Given that such an approach has been introduced for teacher evaluations and personnel decisions in some countries,[32] scholars have started to discuss about its validity with advocates maintaining that student achievements can be improved by selecting teachers on the basis of their VA and critics arguing that VA estimates are poor proxies for teacher quality (Chetty et al. (2014a). In general, this line of research has to face an important difficulty given by the nonrandom sorting of both students and teachers among schools and the nonrandom sorting of students among classrooms, for example, because students interacting badly can be intentionally separated, easy-to-teach students can be assigned to favoured teachers by the principal, students can be allocated to some teachers following parental requests, etc.

By analysing the case of a large urban school district in the US, covering about 2.5 million children in grades 3-8, Chetty et al. (2014a) find that value-added measures, which control for lagged test scores, can be useful in identifying teachers' causal impact on student achievement with little or no bias. In a related paper, Chetty et al. (2014b) analyse whether teachers, who were able to improve students test scores, were simply better at teaching to the test or they enhanced their students' outcomes when they became adult. According to their main findings, this second option occurs, i.e. teachers have long-lasting impacts on student outcomes. Indeed, they show that improvements in teacher VA have positive impact on the probability of college attendance, on the quality of the colleges which students are enrolled to, on their future earnings, on the probability of having children as teenagers, and on the participation in retirement savings plans. Taking a policy oriented perspective, these authors also conclude that «replacing low-VA teachers may therefore be a more cost effective strategy to increase teacher quality in the short run than paying bonuses to retain high-VA teachers. In the long run, higher salaries could attract more high VA teachers to the teaching profession» a benefit which however is not measured in the paper (Chetty et al. (2014b) p. 2636).

Rothstein (2010), however, questions the results obtained with the VA method. The main assumptions underlying such a method do not meet the data on North Caroline used in his paper, and thus the author concludes that the obtained estimates of teachers' effects cannot be interpreted as casual.[33] According to his view, «policies based on these value added modelings will reward or punish teachers who do not deserve it and fail to reward or punish teachers who do» (p. 211). Instead, he suggests that teachers' evaluation should also be based on subjective ratings provided by principals who may have more informations both on the teacher's quality and on the teacher-student matching, i.e. the assignment of easy-to-teach or difficult-to-

[30] For a survey, see Hanushek and Rivkin (2006).

[31] Another line of research has focused the attention on the link between specific teacher characteristics and student achievement, leading however to a mixed set of results (Hanushek and Rivkin (2006)). For example, as far as teacher experience is concerned, it seems that a nonlinear relationship occurs between the quality of teaching and experience, meaning for example that experience effects are more important in the first few years of teaching.

[32] The recent Obama Administration Race to the Top initiative aims at supplying funds to states that engage in reforming schools in such a way to ameliorate teacher and principal effectiveness by connecting teacher evaluations to student growth. Other countries pursuing similar initiatives are United Kingdom, Mexico, Israel, Portugal, and India (Fryer (2013)).

[33] Falsification tests developed by the author shows indeed that future teachers would have important effects on students' past achievement.

teach students. «Of course, this suggestion presumes high-quality principals who have enough time to observe teachers' classrooms and enough training to distinguish good from bad teachers» (p. 212).

Finally, by taking a cross-section viewpoint for 23 developed countries, and using data from the Programme for the International Assessment of Adult Competencies (PIAAC), Hanushek et al. (2014) show that international differences in student performance measured by PISA results can be explained by differences in teachers cognitive skills which are particularly large across countries (with Finland and Japan at the top and Italy and Russian Federation at the bottom).[34] Another interesting result shows that the impact of teacher cognitive skills is higher for students coming from low socioeconomic background than for those coming from high socioeconomic background while the impact of parent cognitive skills goes the other way round. This of course rise important equity issues concerning the policies that could be implemented in order to reduce inequality in the distribution of education with subsequent positive effects in terms of income inequality.

## 5.2. Institutional features of the education system

Given the great variation in national education policies across countries, recent economic research has underlined how different institutional characteristics of the school system can affect students' achievement.[35] In what follows, we concentrate our attention on pre-primary education, school entry-age, school tracking and vocational orientation, school autonomy and accountability.

### 5.2.1. Pre-primary education

The importance of pre-primary education has been stressed especially by the works of Heckman and co-authors who stress the importance of interventions that begin in early childhood to foster noncognitive skills which lay the foundations not only for the future acquisition of cognitive skills but also for success in the labour market and in all other aspects of life. Of course, noncognitive skills are also shaped by families and social environments, but their development through the school system may be particularly important for those children coming from disadvantage environments in order to try to reduce the gap with respect to those coming from more favourable environments. In this sense, pre-primary education can play a fundamental role in fostering skills which, on the one hand, will be inputs into the future learning process, and on the other hand, will augment the stock of future skills which allows to increase the productivity of future investments, as pointed out in section 4 where the two concepts of self-productivity and dynamic complementarity have been analysed. Indeed, self-productivity refers to the fact that skills at birth are due to inherited traits and prenatal investments while skills at later ages rely upon the stock of skills obtained in previous periods and upon investments made previously. Thus, skills acquired earlier are inputs into the learning process which occurs at the next stage, i.e. "skills beget skills." Dynamic complementarity, instead, describes the idea that present investments made by parents, schools, etc. augment the stock of future skills which allows to increse the productivity of future investments (Kautz et al. (2014)).[36] Accordingly, building an early base of skills may improve later-life learning, and this may be more effective with respect to other types of intervention designed for adolescents, especially when targeted at disadvantaged children.[37]

Several pre-primary programmes which have taken place in the United States, and surveyed by Kautz et al. (2014), show that they had, indeed, positive effects not only in terms of students achievement, but also on other variables such as reduced participation in criminal activity, decreased substance abuse, improved health status, etc..[38] Studies for other countries are few, but tend to find similar results (Checchi et al. 2013).[39] The

[34] We refer to that paper for a discussion on the econometric techniques used and causality issues.

[35] As noticed by Hanushek and Wößmann (2011), national educational institutions may be correlated to other unobserved country characteristics that, in their turn, are related to academic achievement. Several econometric techniques have been developed to take into account this problem.

[36] There is also another channel stressed by such authors which should be taken into account. It refers to static complementarity given that the benefits of an investment relies upon the present stock of skills, i.e. high-skill children are those who benefit the most by additional investments.

[37] However, also adolescent interventions may be more effective when they concentrate on the development of noncognitive skills. According to Kautz et al. (2014), «the available evidence suggests that the most promising adolescent interventions are those that target non-cognitive skills as well as programmes that offer mentoring, guidance and information» (p. 8). Indeed, «while there is hard evidence on the importance of the early years in shaping all skills, many non-cognitive skills are more malleable than cognitive skills at later ages» (p. 66).

[38] See, for example, the results for the Perry Preschool Programme and the Abecedarian Programme in Kautz et al. (2014).

same type of result is also found in cross-section analyses. For example, Schuetz et al. (2008) show a positive relationship between the duration of the preschool cycle and students' academic achievement while Schneeweis (2011) finds a negative association between preprimary enrollment and the migrant achievement gap.

### 5.2.2. School entry-age

Usually, in all countries, the education system fixes a single cutoff date for school eligibility. This implies that, when school starts, some students are older, and thus potentially more mature, than others, and this could affect not only their academic peformance but also their future earnings. As already stressed, skills accumulated in a given period are complementary to learning in the following period, and thus early differences in maturity could be transferred to the following periods through the educational system. Indeed, the way the school system is organized, as age at which tracking occurs or sorting students into ability-specific curriculum groups, may propagate early relative age effects. For example, the fact that relatively old children have early advantages in the process of skills' accumulation may also affect the long-run differences in educational achievements depending on whether, according to the school system of a country, children are separated or not in different ability-specific curriculum groups during the primary grades.

The link between age at school start and in-school tests has been the topic of much research whose typical finding is that older school starters perform better at school than younger ones. For example, a cross-country study is performed by Bedard and Dhuey (2006), using data from the Trends in International Mathematics and Science Study (TIMSS) across OECD countries.[40] This work finds a large relative age effect that has a long-lasting impact on student performance: oldest students perform better than the youngest students both at the fourth grade level and the eighth grade level, even if this age effect is reduced between the two grades, and further, for the data from British Columbia, Canada and the United States, oldest students are more likely to attend university. Several country-level studies have been also carried on. For instance, for Sweden, Fredriksson and Öckert (2014) show that a higher school starting age increases educational attainment in the long run. For Germany, Mühlenweg and Puhani (2010) present estimates of the causal impact of school-entry age on track attended, finding that younger students are only two-thirds as likely to attend the academic track than older students. For Austria, Schneeweis and Zweimüller (2014) show that relatively young students are significantly less likely to be enrolled in a high-track school than old students, and that such relative-age effect amplifies existing differences in socioeconomic parental backgrounds, thus magnifying existing socioeconomic inequalities. Finally, for Italy, Ponzo and Scoppa (2014) show that younger students score lower than older students at the fourth, the eighth, and the tenth grade, and that older students are more likely to be enrolled in more academic schools rather than in vocational schools.[41]

### 5.2.3. School tracking and vocational orientation

National school systems also vary with respect to tracking, i.e. to the extent to which secondary school students are sorted into different tracks depending on their learning skills (academic versus vocational schools) as opposed to comprehensive schooling. Such ability grouping into different school types may take place at different students' age,[42] and it has been mostly analysed in terms of equity of student performances and average achievement.[43]

---

[39] Braga et al. (2013) analyse the case of European countries and show that reforms extending preprimary schooling and/or favouring the access to education through raise in tracking age exhibit, on the one hand, positive correlation with average years of education in the population and, on the other hand, a negative association with inequality in the educational distribution and persistence from one generation to the other.

[40] See the discussion in the paper on the difficulties in studying the causal impact of early relative age on later outcomes.

[41] See Black et al. (2011) for a paper on Norway that does not find significant effects of school starting age on the outcomes of adults, even if it finds a large positive effect on in-school tests.

[42] For example, in Germany and Austria tracking occurs at the age of 10, in Hungary, the Czech Republic, Slovakia, and Turkey at the age of 11, in the Netherlands and in Belgium at the age of 12, in Luxembourg at the age of 13, in Italy at the age of 14, and in Finland and Sweden at the age of 16. Other countries, as the U.S. have tracking within schools but not across schools.

[43] It should be pointed out that some countries, typically in Europe, divide students into different schools, i.e. either vocational or academic schools, while other countries such as the United States or Canada sort students into different classrooms within a school.

The pros and the cons positions for early tracking depend on both peer group effects and teaching effects. On the one hand, proponents of school tracking mantain that it allows a more efficient school organization, i.e. a maximization of students' performance (at least at the top) because more homogeneous classes may facilitate learning via targeted curricula, and teachers are more effective when they teach in homogeneous classes because they can focus their teaching. On the other hand, opponents claim that it may systematically disadvantage weaker students by separating them too early; some students could end up in the wrong track if ability is measured with noise; the interaction between low-performing and high-performing students may benefit both because the formers can take advantage of the help of the latters, and the latters can consolidate their knowledge by explaining the subject materials to the formers (Piopiunik (2014)). In particular, even if, in the empirical literature, there is no consensus on whether peer group effects are important and on their possible size, it should be pointed out that, from an efficiency point of view, peer effects may positively affects the production of human capital only if they are non-linear, i.e. moving a talented student from the vocational to the academic track increases the human capital in the latter track by a greater amount than the loss in the former track (Brunello and Checchi (2007)).[44]

The literature on this issue is already quite large and has concentrated its attention on both the effects of tracking on overall student achievement and on the distribution of student achievement, i.e. equity considerations. For example, using the data set on test scores PISA 2006 for 38 countries, Checchi et al. (2013) do not find evidence of the position in favour of early tracking both for the average and the top performers.[45] An analysis on the association between tracking and equity in students' achievement is also performed by Hanushek and Wößmann (2011) in an international perspective. Using the standard deviation in student test scores, they compare the inequality in reading achievement at the primary school (in PIRLS) and at the secondary school (in PISA 2003) among countries with and without tracking before the age of 16. According to their analysis, inequality in students' achievement sistematically increases in countries with early tracking, while it decreases in countries without tracking.

Tracking, however, could also be related to another type of inequality in terms of educational opportunity by social origin. When compared to comprehensive education systems, earlier tracking systems could have larger skill inequalities between students coming from different social background. In this respect, Schuetz et al. (2008) find that inequality of opportunity, i.e. the extent to which the student achievement depends on her/his family background, is significantly smaller the later the age at which tracking starts. In the same vein, Brunello and Checchi (2007) show that, tracking tends to augment the effect of family background on future earnings.[46] Recently, Piopiunik (2014), by using a difference-in differences approach, has investigated the effect of timing of tracking on student achievement following a reform that took place in Bavaria in 2000 that anticipated by two years the timing when basic and middle school students are allocated to different tracks. His results show that such reform had a negative effect both on basic and middle students' achievement, and that the performance dispersion increased suggesting a decrease in equality of opportunity.

### 5.2.4. School autonomy

School autonomy is an important institutional feature of the school system that is often claimed to be a driver of better student outcomes. Local decision-makers may have an informational advantage with respect to a central decision-maker on the capacity of their schools, and on the local students needs and preferences. Given that parents can change school by voting with their feet, local decision-makers can be more responsive to students demand, and accordingly make better decisions on how to allocate resources. Of course, this requires free school choice by parents, and their capacity to monitor the educational policied offered by schools via public information on schools performance. This can lead to a sort of yardstick competition among schools which can promote the adoption of more effective teaching methods in improving students performance. On the drawback side, teachers could be induced to ‘teaching to the test’ spending less time

In this latter case, students could be in a high track for one subject and in a low track for another one, and they should be able to switch between tracks more easily than in the case of tracking between schools. For a survey on this topic, see Betts (2011).

[44] The presence of peer group effects has been studied by theoretical (e.g. Epple and Romano, 1998 and Epple et al. 2006) and empirical literature. Empirical findings however are mixed also for several estimation difficulties, e.g. selection and attrition biases and data problems. See, for example, Sacerdote (2001) and Hoxby (2000) for papers finding positive peer effects.

[45] See such paper for references to other studies that find contradicting results.

[46] See this paper also for a review of early literature both on country case studies and cross-country analysis.

and effort in all other aspects of schooling such as socialization, self-confidence, critical thinking, etc. which are not measured by standardized tests, but which play a fundamental role of schooling (Verschelde et al. (2015)).[47]

Still on the shortcomings, school autonomy could not allow to attain common standards across a country, and it could also lead to a principal-agent problem, i.e. local decision-makers could behave opportunistically if their interests are not perfectly in line with the aim of ameliorating student outcomes, and these are not monitored by appropriate centralized accountability procedures (Hanushek and Wößmann (2011)). Examples of accountability measures to align the interests of schools and the government are central exit exams and regular inspections to check that the teaching process matches the centrally imposed standards. However, it should also be pointed out, as it is done by the psycological literature, that such monitoring by the principal can be associated to some peculiar costs. The agents could lower their effort if monitoring by the principal is perceived as a signal of distrust. Extrinsic motivations obtained through monitoring and/or price incentives can have a crowding-out effect on intrinsic motivations which are so important for a high teaching quality (Verschelde et al. (2015)).

The impact of school autonomy on students scholastic career has been analysed by performing both cross-country and within-country evidence. For example, by using a panel of four waves of PISA scores (2000, 2003, 2006 and 2009) for 42 countries, Hanushek, Link and Wößmann (2013) show that the impact of school autonomy on students achievement is very heterogeneous, and it depends on the level of economic and educational development of a country: School autonomy leads to considerable gains in countries with strong institutions while it leads to losses in countries where institutions are weak. Interestingly, the effect of more autonomy is larger in countries where the school system is accountable by central exit exams. On the contrary, when there are not external exit exams, Hanushek and Wößmann (2011) report that, in some areas, school autonomy is negatively associated with student achievement. Further, they point out that students performance is better in schools that have autonomy in process and personnel decisions areas such as purchase of supplies, budget allocations within schools, textbooks and instructional method choice, hiring and rewarding teachers, and also if teachers have the possibility to choose appropriate teaching methods. By contrast, they also report that students achievement is negatively associated to school autonomy in budget formation and teacher autonomy in choosing the subject matter taught in class.[48]

In order to isolate the school autonomy effects from country-specific effects, i.e. institutional and cultural differences, and school-type effects, i.e. coming from comparing different types of schools with different degree of autonomy,[49] a paper by Verschelde et al. (2015) concentrates the attention on a within country, within school type variation of autonomy which has recently occurred in Flanders (Belgium). For the additional funds above the centrally imposed funding system, different schools' staff (direction and teachers) may have different degree of freedom in allocating such resources. Overall, by combining data on school-level and pupil-level from PISA 2006 with a semi-parametric hierarchical model, their findings confirm a positive effect of school autonomy on budget allocation on students performance measured by PISA tests. In particular, they find that mathematics test scores are 0.1 standard deviations higher in schools with a considerable autonomy over the budget allocation with respect to schools without such autonomy. As previously stressed, also their analysis points out the importance of an effective accountability system in order to make the positive effects of autonomy described above to dominate the negative ones. The expected benefits from local staff empowerment are thus country-specific, and they can only be reaped in those countries where there are effective accountability systems.

### 5.2.5. School accountability

School accountability refers to the evaluation of school performance through aggregate student performance on standardized tests. Based on school accountability results,[50] schools can be explicitly

[47] For more details on this point, see also the next section.

[48] See Braga et al. (2013) for an analysis on European countries showing that reforms augmenting school autonomy and accountability are, on the one hand, positively correlated with mean educational attainment but, on the other hand, with inequality in the distribution of educational attainments and intergenerational persistence.

[49] See, for example, the literature on charter schools. For a brief review and useful references, see Grazzini and Petretto (2014).

[50] In some countries such as England, the United States, and Chile, school accountability ratings are publicly available. In other countries, they are used for internal purposes.

rewarded, e.g. with more resources and/or more autonomy in spending, or sanctioned, e.g with threats of restructuring/closing low-performing schools or withdrawal of autonomy. When accountability results are publicly reported, schools can also be implicitly rewarded or sanctioned through the pressure by the parents and the community to improve.

The economic rationale behind such procedure rests on the principal-agent problem: Policy-makers, parents, and local communities may acquire more information on each school performance thanks to standardized student test scores which constitute a common metric to make comparisons among schools. However, it is important to stress that there are different methods to measure school performance, and the economic literature has developed two main approaches (Figlio and Loeb (2011)). 'Status' measures evaluate schools' performance on the basis of their level of performance: For example, average test score obtained by students in each school or percentage of students whose test score is above or below a thresold value. 'Value-added' measures, instead, judge school's performance on the basis of changes in test scores obtained by the same students in a given period, for example one year. Of course, the two measures evaluate different aspects of school performance (absolute versus relative), and provide different incentives to schools: Status-based measures encourage schools to improve the performance of the students' average test score and/or that of the top and/or bottom performers while growth-based measures encourage schools to augment their students' performance taking into account their different starting points. Since these are usually highly correlated to family backgrounds, value-added measures are considered fairer by some scholars and school operators.

The accountability literature has thus tried to estimate whether school accountability may be effective in increasing students' performance. On the one hand, such monitoring could be effective in improving schools performance: Figlio and Loeb (2011) provide a survey of papers that find some positive results for the case of the United States. However, on the other hand, as stressed by the same authors, such procedure could also induce schools to behave strategically. For example, the available evidence supports the idea that teachers could concentrate on subjects tested, i.e. "teaching to the test", and put aside all other desirable outcomes of learning such as critical thinking, citizenship and work ethic. Further, schools could adopt more selective procedures in order to admit better students and/or allocate disadvantage students in special education so to exclude them from participating to the official exams. Schools then can obtain higher test scores without improving their teaching quality, but of course with sizeable negative effects in terms of equity, i.e. unequal distribution of education (Checchi et al. (2013) and Braga et al. (2013)).

School accountability can also be judged with respect to the existence of central curriculum-based exit exams which characterize different educational systems. The aim of such exams is to provide a standardization of output which may favour competition among schools when the accountability of the schools is judged via their performance. Further, external school-leaving exams can be used as a signaling device by students in order to transfer information to the employers about their productivity in a labour market characterized by adverse selection. Given their signaling power, and thus their consequent potential future reward on the labour market, central exit exams should promote both students' learning and parents' supervision on the education process. Taking such perspective, Hanushek and Wößmann (2011) show that students from countries with external exit-exams score better on international tests than students from countries without external exit-exams. Checchi et al. (2013) find, instead, that for mathematics, the average peformance and the performance at the top and at the bottom are not linked to the existence of central exams.

As a final remark, it should be stressed the fact that school accountability measures are not perfectly able to monitor school efficiency, i.e. the «effectiveness with which schools use their resources to maximise students outcomes, given the students they serve» (Figlio and Loeb (2011), p. 393). A low school performance could be due not to inefficient behaviours by the school or the teachers, but to an insufficient amount of resources to meet the accountability target given the starting point of the enrolled students. School accountability, indeed, depends on school financing.

## 6. Concluding remarks

This paper has concentrated its attention on the role played by the quality of education, and has presented a brief and selective overview on some recent studies analyzing, on the one hand, some important determinants of education related to school resources, and institutional features of the education system, and on the other hand, the economic consequences of the quality of education on future earnings and growth.

These studies are relatively recent but, despite their limitations and the necessity to go on in further investigations, they can offer important hints on fundamental determinants of education, and on its substantial economic and social benefits. In particular, given that in the education sector, as in many other areas of public policy intervention, «slogans often replace hard evidence» (Kautz et al. (2014) p. 12), this literature, which is already very extended, can be useful in enlightening some pros and cons of different educational policies, and thus for the designing of more effective policies. Unfortunately, attempting to derive normative prescriptions from these works is not an easy task for all the limits that this survey has tried to illustrate, and also because all possible lessons which can be learnt from this literature always need to be interpreted, and thus adapted, taking into account the institutional features of the different national school systems.

As it has been stressed in this work, one of such lessons points out the importance of measuring students, teachers, and principals performance for the evaluation of the educational process, and the relevance of such issue is not even any more at the heart of the academic debate but also of the public opinion discussion. However, several recent studies initiated by James Heckman have stressed how achievement tests for students are not able to capture important dimensions, and in particular those non-cognitive skills which instead show to be highly predictive in meaningful life outcomes. The analysis of such an issue with the development of reliable instruments to evaluate non-cognitive skills seems thus one of the most promising field of research in this area on which further investigations are called for. This would indeed provide policy-makers with still more accurate studies with respect to which evaluate present educational policies or elaborate new ones, especially in the case of early childhood and elementary school programmes which seem to show long lasting effects on individual performances preeminently for those individuals coming from disadvantaged backgrounds.

The attention for the development of better educational policies is of course valuable from an equity point of view but, as the literature on the economics of education has stressed from its beginning, there exist as much efficiency reasons to pursue such an aim. Interestingly, as it has been already pointed out,[51] the two objectives may even not originate a trade-off in some cases. For example, within the debate on whether a school system should be sufficiently egalitarian to favour basic skills for all so that established technologies can be implemented, or it should concentrate more resources on top performers who will be more likely drivers of innovations, some recent evidence by Hanushek and Wößmann (2011) shows that both basic-skills and top-performing dimensions seem to be separately important for growth.

In this respect, especially following a period of deep crisis, the improvement of the quality of education can be one of the main strategy to adopt in trying to foster growth, even if, as it is well known, its effects are usually not for tomorrow but for the long run. This long run perspective, of course, can explain why it may be difficult for politicians to treat this issue both before elections at a political platform level and, later, at a legislative level: educational reforms need a long time for producing results whose main beneficiaries are future generations.[52] However, a more comprehensive outlook including the point of view of different generations could be challenging in that, for example, educational policies strengthening the human capital investment of young generations and thus their future income perspectives may have additionally positive effects also for the welfare of older generations both from an altruistic point of view and in terms of intergenerational transfer of wealth.

## References


Acemoglu, D. (2009), Introduction to Modern Economic Growth, Princeton University Press, USA.

Acemoglu, D., Gallego, F.A., Robinson, J.A. (2014), Institutions, Human Capital, and Development, Annual Review of Economics, 6, 875-912, DOI: 10.1146/annurev-economics-080213-041119.

Aghion, P., Howitt, P. (1998), Endogenous Growth Theory, Cambridge, Massachusetts, The MIT Press.

Barro, R.J., Sala-i-Martin, X. (1995), Economic Growth, New York, McGraw-Hill.


[51] See, for example, the case of public aids in favour of skilled students coming from disadvantaged families.

[52] See Braga et al. (2013) for an analysis of the relationship between party ideologies and type of reforms, i.e. those affecting students' achievement by raising the bottom tail of the distribution versus those improving the upper tail. See the same paper also for a discussion on some features of different education policies which may affect the policy-maker choices, i.e. sequencing of reforms, availability of public resources, and ideological orientation of government.

Becker, G. (1964), Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education, New York, Columbia University Press.

Bedard, K., Dhuey, E. (2006), The Persistence of Early Childhood Maturity: International Evidence of Long-Run Age Effects, The Quarterly Journal of Economics, 1437-1472, DOI: 10.1093/qje/121.4.1437.

Benhabib J., Spiegel M.M. (1994), The Role of Human Capital in Economic Development: Evidence from Aggregate Cross-Country Data, Journal of Monetary Economics, 34, 2, 143-174, DOI: 10.1016/0304-3932(94)90047-7.

Betts, J.R. (2011), The Economics of Tracking in Education, in Eric A., Hanushek, Stephen, Machin, Ludger, Wößmann (eds.), Handbook in Economics of Education, vol. 3, North-Holland Elsevier, USA.

Bils, M., Klenow, P.J. (2000), Does Schooling Cause Growth?, American Economic Review, 90, 5, 1160-1180, DOI: 10.1257/aer.90.5.1160.

Black, S.E., Devereux, P.J., Salvanes, K.G. (2011), Too Young to Leave the Nest? The Effects of School Starting Age, The Review of Economics and Statistics, 93:2, 455-467, DOI:10.1162/REST_a_00081.

Björklund, A., Salvanes, K.G. (2011), Education and Family Background: Mechanisms and Policies, in Eric A., Hanushek, Stephen, Machin, Ludger, Wößmann (eds.), Handbook in Economics of Education, vol. 3, North-Holland Elsevier, USA.

Bosworth, R. (2014), Class Size, Class Composition, and the Distribution of Student Achievement, Education Economics, 22:2, 141-165, DOI: 10.1080/09645292.2011.568698.

Braga, M., Checchi, D., Meschi, E. (2013), Educational Policies in a Long Run Perspective, Economic Policy, 28:73, 45-100, DOI: 10.1111/1468-0327.12002.

Breton, T.R. (2013), The Role of Education in Economic Growth: Theory, History and Current Returns, Educational Research, 55:2, 121-138, DOI: 10.1080/00131881.2013.801241.

Brunello, G., Checchi, D. (2007), Does School Tracking Affect Equality of Opportunity? New International Evidence, Economic Policy, 22, 781-861, DOI: 10.1111/j.1468-0327.2007.00189.x.

Card, D. (1999), The Causal Effect of Education on Earnings, in O. Ashenfelter and D. Card (eds.), Handbook of Labor Economics, vol. 3, , North-Holland Elsevier, USA.

Card, D. (2001), Estimating the Return to Schooling: Progress on some Persistent Econometric Problems, Econometrica, 69:5, 1127-1160, DOI: 10.1111/1468-0262.00237.

Checchi D. (2006), The Economics of Education. Human Capital, Family Background and Inequality, Cambridge, Cambridge University Press.

Checchi, D., van de Werfhorst, H., Braga, M., Meschi E. (2013), The Policy Response: Education, in Wiemer Salverda, Brian Nolan, Daniele Checchi, Ive Marx, Abigail McKnight, István György Tóth, and Herman van de Werfhorst (eds.), Changing Inequalities and Societal Impacts in Rich Countries: Analytical and Comparative Perspectives, Oxford University Press, UK.

Chetty, R., Friedman, J.N., Hilger, N., Saez, E., Schanzenbach, D.W., Yagan, D. (2011), How Does your Kindergarten Classroom Affect your Earnings? Evidence from Project Star, Quarterly Journal of Economics, 126:4, 1593-1660, DOI: 10.1093/qje/qjr041.

Chetty, R., Friedman, J.N., Rockoff, J.E. (2014a), Measuring the Impacts of Teachers I: Evaluating Bias in Teacher Value-Added Estimates, American Economic Review, 104:9, 2593-2632, DOI: 10.1257/aer.104.9.2593.

Chetty, R., Friedman, J.N., Rockoff, J.E. (2014b), Measuring the Impacts of Teachers II: Teacher Value-Added and Student Outcomes in Adulthood, American Economic Review, 104:9, 2633-2679, DOI: 10.1257/aer.104.9.2633.

Cunha, F., Heckman, J. (2007), The Technology of Skill Formation, American Economic Review, 97:2, 31-47, DOI: 10.1257/aer.97.2.31.

Dee, T.S. (2004), Are there Civic Returns to Education?, Journal of Public Economics, 88, 1697-1720, DOI: 10.1016/j.jpubeco.2003.11.002.

Dickson, M., Harmon, C. (2011), Economic Returns to Education: What We Know, What We Don't Know, and Where We Are Going – Some Brief Pointers, Economics of Education Review, 30, 1118-1122, DOI: 10.1016/j.econedurev.2011.08.003.

Epple, D., Romano, R.E. (1998), Competition Between Private and Public Schools, Vouchers, and Peer-Group Effects, American Economic Review, 88, 1, 33-61.

Epple, D., Romano, R. Sieg, H. (2006), Admission, Tuition, and Financial Aid Policies in the Market for Higher Education, Econometrica, 74, 885-928, DOI: 10.1111/j.1468-0262.2006.00690.x.

Figlio, D., Loeb, S. (2011), School Accountability, in Eric A., Hanushek, Stephen, Machin, Ludger, Wößmann (eds.), Handbook in Economics of Education, vol. 3, North-Holland Elsevier, USA.
Fredriksson, P., Öckert, B. (2014), Life-Cycle Effects of Age at School Start, The Economic Journal, 124, 977-1004, DOI: 10.1111/ecoj.12047.
Fredriksson, P., Öckert, B., Oosterbeek, H. (2013), Long-Term Effects of Class Size, Quarterly Journal of Economics, 249-285, DOI: 10.1111/ecoj.12047.
Fryer, R.G. (2013), Theacher Incentives and Student Achievement: Evidence from New York City Public Schools, Journal of Labour Economics, 31:2, 373-407, DOI: 10.1086/667757.
Gennaioli, N., La Porta, R., Lopez-De-Silanes, F., Shleifer, A. (2013), Human Capital and Regional Development, Quarterly Journal of Economics, 128 (1): 105-164, DOI:10.1093/qje/qjs050.
Gradstein, M., Justman, M., Meier, V. (2005), The Political Economy of Education: Implications for Growth and Inequality, Cambridge, The MIT Press.
Grazzini, L. (2009), Istruzione, crescita e democrazia: le teorie delle complesse relazioni, Politica Economica, 25(2), 233-273, DOI: 10.1429/30318.
Grazzini L., Petretto A. (2014), Public-Private Partnership and Competition in Health-Care and Education, Italian Antitrust Review, 1(2), 91-116, DOI: http://dx.doi.org/10.12870/iar-10198.
Grossman, M. (2006), Education and Nonmarket Outcomes, in Eric A., Hanushek, Finnis, Welch (eds.), Handbook in Economics of Education, vol. 1, North-Holland Elsevier, USA.
Hanushek, E.A., Kimko, D.D. (2000), Schooling, Labor-Force Quality, and the Growth of Nations, American Economic Review, 90:5, 1184-1208**,** DOI: 10.1257/aer.90.5.1184.
Hanushek, E.A., Link, S., Wößmann, L. (2013), Does School Autonomy Make Sense Everywhere? Panel Estimates from PISA, Journal of Development Economics, 104, 212-232, DOI:10.1016/j.jdeveco.2012.08.002.
Hanushek, E.A., Piopiunik, M., Wiederhold, S. (2014), The Value of Smarter Teachers: International Evidence on Teacher Cognitive Skills and Student Performance, NBER WP N. 20727.
Hanushek, E.A., Rivkin, S.G. (2006), Teacher Quality, in Eric A., Hanushek, Finnis, Welch (eds.), Handbook in Economics of Education, vol. 2, North-Holland Elsevier, USA.
Hanushek, E.A., Rivkin, S.G. (2012), The Distribution of Teacher Quality and Implications for Policy, Annual Review of Economics, 4, 131-157, DOI: 10.1146/annurev-economics-080511-111001.
Hanushek, E.A., Wößmann, L. (2008), The Role of Cognitive Skills in Economic Development, Journal of Economic Literature, 46:3, 607-668, DOI: 10.1257/jel.46.3.607.
Hanushek, E.A., Wößmann, L. (2011), The Economics of International Differences in Educational Achievement, in Eric A., Hanushek, Stephen, Machin, Ludger, Wößmann (eds.), Handbook in Economics of Education, vol. 3, North-Holland Elsevier, USA.
Hanushek, E.A., Wößmann, L. (2012), Do Better Schools lead to more Growth? Cognitive Skills, Economic Outcomes, and Causation, Journal of Economic Growth, 17, 267-321, DOI 10.1007/s10887-012-9081-x.
Hanushek, E.A., Wößmann, L. (2014), Institutional Structures of the Education System and Student Achievement: A Review of Cross-country Economic Research, in R. Strietholt, W. Bos, J. Gustafsson, M. Rosén (Eds.), Educational Policy Evaluation through International Comparative Assessments, Waxmann Verlag GmbH, Münster-New York.
Hanushek, E.A., Schwerdt, G., Wiederhold, S., Wößmann, L. (2015), Returns to Skills around the World: Evidence from PIAAC, European Economic Review, 73, 103-130, DOI:10.1016/j.euroecorev.2014.10.006.
Harmon, C., Oosterbeek, H., Walker, I. (2003), The Returns to Education: Microeconomics, Journal of Economic Surveys, 17:2, 115-155, DOI: 10.1111/1467-6419.00191.
Heckman, J.J., Stixrud, J., Urzua, S. (2006), The Effects of Cognitive and Noncognitive Abilities on Labour Market Outcomes and Social Behaviour, Journal of Labour Economics, 24:3, 411-482, DOI: 10.1086/504455.
Hoxby, C.M. (2000), Peer Effects in the Classroom: Learning from Gender and Race Variation, NBER W. P. No 7867.
Kautz, T., Heckman, J.J., Diris, R., Weel, B., Borghans, L. (2014), Fostering and Measuring Skills: Improving Cognitive and Non-Cognitive Skills to Promote Lifetime Success, Report prepared for the Organisation of Economic Co-operation and Development, Paris.
Krueger, A.B. (1999), Experimental Estimates of Education Production Functions, The Quarterly Journal of Economics, 114:2, 497-532, DOI: 10.1162/003355399556052.

Krueger, A.B. (2003), Economic Considerations and Class Size, The Economic Journal, 113, F34-F63, DOI: 10.1111/1468-0297.00098.
Krueger, A.B., Lindahl, M. (1999), Education for Growth in Sweden and the World, Swedish Economic Policy Review, 6, 289-339.
Krueger, A.B., Lindahl, M. (2001), Education for Growth: Why and for Whom?, Journal of Economic Literature, 39, 1101-1136**,** DOI: 10.1257/jel.39.4.1101.
Leuven, E., Oosterbeek, H. (2011), Overeducation and Mismatch in the Labor Market, in Eric A., Hanushek, Stephen, Machin, Ludger, Wößmann (eds.), Handbook in Economics of Education, vol. 3, North-Holland Elsevier, USA.
Lochner, L. (2011), Non-Production Benefits of Education: Crime, Health and Good Citizenship, in Eric A., Hanushek, Stephen, Machin, Ludger, Wößmann (eds.), Handbook in Economics of Education, vol. 3, North-Holland Elsevier, USA.
Lucas, R.E. (1988), On the Mechanism of Economic Development, Journal of Monetary Economics, 22(1), 3-42, DOI:10.1016/0304-3932(88)90168-7.
Montenegro, C.E., Patrinos, H.A. (2014), Comparable Estimates of Returns to Schooling Around the World, World Bank Policy Research WP N.7020.
Mincer, J. (1974), Schooling, Earnings, and Experience, New York, Columbia University Press.
Mühlenweg, A.M., Puhani, P.A. (2010), The Evolution of the School-Entry Age Effect in a School Tracking System, Journal of Human Resources, 45:2, 407-438, DOI: 10.3368/jhr.45.2.407.
Murphy, K.M., Shleifer, A., Vishny, R.W. (1991), The Allocation of Talent: Implications for Growth, Quarterly Journal of Economics, 106:2, 503-530, DOI: 10.2307/2937945.
Nelson, R.R., Phelps, E.S. (1966), Investments in Humans, Technological Diffusion, and Economic Growth, American Economic Review, 56(1/2), 69-75.
OECD (2014), PISA 2012 Results in Focus. What 15-Year-Olds Know and What they Can Do with What they Know, Paris and Washington, D.D., OECD.
Oreopoulos, P. Salvanes, K.G. (2011), Priceless: The Nonpecuniary Benefits of Schooling, Journal of Economic Perspectives, 25:1, 159-184, DOI: 10.1257/jep.25.1.159.
Piopiunik, M. (2014), The Effects of Early Tracking on Student Performance: Evidence from a School Reform in Bavaria, Economics of Education Review, 42, 12-33, DOI:10.1016/j.econedurev.2014.06.002.
Ponzo, M., Scoppa, V. (2014), The Long-lasting Effects of School Entry Age: Evidence from Italian Students, Journal of Policy Modeling, 36, 578-599, DOI:10.1016/j.jpolmod.2014.04.001.
Romer, P. (1990), Endogenous Technological Change, Journal of Political Economy, 98:5, 71-102, DOI: 10.1086/261725.
Rothstein, J. (2010), Teacher Quality in Educational Production: Tracking, Decay, and Student Achievement, Quarterly Journal of Economics, 175-214, DOI: 10.1162/qjec.2010.125.1.175.
Sacerdote, B. (2001), Peer Effects with Random Assignment: Results for Dartmouth Roommates, Quarterly Journal of Economics, 116, 2, 681-704, DOI: 10.1162/00335530151144131.
Sauer, P., Zagler, M. (2012), Economic Growth and the Quantity and Distribution of Education: A Survey, Journal of Economic Survey, 26:5, 933-951, DOI: 10.1111/j.1467-6419.2011.00713.x.
Schneeweis, N. (2011) Educational Institutions and the Integration of Migrants, Journal of Population Economics, 24:4, 1281-1308, DOI 10.1007/s00148-009-0271-6.
Schneeweis, N., Zweimüller, M. (2014), Early Tracking and the Misfortune of Being Young, The Scandinavian Journal of Economics, 116:2, 394-428, DOI: 10.1111/sjoe.12046.
Schuetz, G., Ursprung, H.W., Wößmann, L. (2008), Education Policy and Equality of Opportunity, Kyklos, 61:2, 279-308, DOI: 10.1111/j.1467-6435.2008.00402.x.
Schultz, T.W. (1961), Investment in Human Capital, American Economic Review, 51:1, 1-17.
Spence, M. (1973), Job Market Signalling, Quarterly Journal of Economics, 87, 355-379, DOI:10.2307/1882010.
Stevens, P., Weale, M. (2004), Education and Economic Growth, in International Handbook on the Economics of Education, Geraint Johnes e Jill Johnes (eds.), Cheltenham, Edward Elgar.
Stiglitz, J. (1975), The Theory of «Screening», Education and the Distribution of Income, American Economic Review, 64:3, 283-300.
Sunde, U., Vischer, T. (2015), Human Capital and Growth: Specification Matters, Economica, 82, 368-390, DOI: 10.1111/ecca.12116.

Temple, J. (1999), A Positive Effect of Human Capital on Growth, Economics Letters, 65, 131-134, DOI: 10.1016/S0165-1765(99)00120-2.

Todd, P.E., Wolpin, K.I. (2003), On the Specification and Estimation of the Production Function for Cognitive Achievement, The Economic Journal, 113, F3-F33, DOI: 10.1111/1468-0297.00097.

Todd, P.E., Wolpin, K.I. (2007), The Production of Cognitive Achievement in Children: Home, School and Racial Test Score Gaps, Journal of Human Capital, 1:1, 91, 136, DOI: 10.1086/526401.

Topel, R. (1999), Labour Markets and Economic Growth, in Handbook of Labour Economics, Orley Ashenfelter e David Card (eds.) Amsterdam, North Holland.

Trostel, P., Walker, I., Woolley, P. (2002), Estimates of the Economic Return to Schooling for 28 Countries, Labour Economics, 9, 1-16, DOI: 10.1016/S0927-5371(01)00052-5.

Vandenbussche, J., Aghion, P., Meghir, C. (2006), Distance to Frontier, Growth, and the Composition of Human Capital, Journal of Economic Growth, 11, 97-127, DOI 10.1007/s10887-006-9002-y.

Verschelde M., Hindriks, J., Rayp, G., Schoors, K. (2015), School Staff Autonomy and Educational Performance: Within-School-Type Evidence, Fiscal Studies, 1-29, DOI: 10.1111/1475-5890.12048.

Wößmann, L. (2003), Specifying Human Capital, Journal of Economic Surveys, 17(3), 239-270, DOI: 10.1111/1467-6419.00195.