HUMAN CAPITAL AND ECONOMIC GROWTH: A REVIEW ESSAY

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Abstract
Human capital as a critical engine of economic growth is present in many empirical and theoretical body of knowledge on growth models and theory. However, the conclusion on its importance as a driver of economic growth remains inconclusive. The aim of this study is to provide and detailed overview on theoretical and empirical research investigating the role of human capital in the economic growth phenomena. Measuring human capital remains the main obstacle to assessing the importance of human capital and education in economic growth. The time lag present causes additional restrictions in the schooling process itself which in the today dynamic and globalized world present a real obstacle to measuring human capital role in growth models. Costs principle in measuring human capital proxy may not be a best approach to use in growth accounting models. Other not quantitative (subjective) factors affect human capital to a degree not less than quantitative are like motivation, commitment, vision. These factors have to be accounted for if an adequate fit for proxy of human capital in growth models in future prospective research on endogenous growth models and theories.

Keywords: schooling, growth, human capital, growth models, knowledge economy

JEL Classification: E24, J24, O15, O40.

Introduction

The relevance of human capital as the driver of economic growth has been acknowledged by many theoretical and empirical studies. It becomes even more significant in the business conditions of „knowledge economy". Every year new empirical results are to be found that confirm this statement. No matter from which perspective the researchers start what is common to all of them is a growing interest in the topic that arises from the premise of the crucial role of human capital in shaping economic growth direction.

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The purpose of this paper is to present the conventional and new concepts of human capital which are to be found in the theoretical and empirical work on economic growth. The authors discuss the advantages and shortcomings of alternative concepts and its' representativeness as relevant fundamental determinant in the proxy human capital determinant. In order, to summarize, the most influential results on that topic a thorough analysis of the available human capital-related literature was conducted (a desk research method was used). The paper deals with both theoretical and empirical work. Its aim is to confront different growth theories with the empirical results, and in doing so a distinction is made between the exogenous and endogenous growth models.

This review essay is structured as follows: after the introduction part, in the chapter 2 the authors present the fundamental concepts of human capital represented in theories of economic growth. The chapter ends with the insight into the two primary perspectives on the source of economic growth, accumulation rate and the stock of human capital. In the following chapter, chapter 3, a list of models of human capital and economic growth with exogenous technical progress is given and interpreted. Chapter 4 deals with the theories of human capital and endogenous economic growth, i.e., the human capital externalities, followed by the chapter 5 in which the problem of reverse causation is discussed. In the chapter 6 the authors summarize the empirical work on human capital and economic growth by stressing the main differences between studies based on the used methods, focus on the research and scope of the research. The paper ends with conclusion remarks in which summary of the research results is given and commented. The list of references follows the main findings and implications (policy implications and implications for future research work).

1. The concept of human capital in theories of economic growth

Human capital is a complex term that eschews a simple definition and measurement and is a concept that has been investigated from a variety of perspectives by social scientist (Savvides and Stengos, 2009:4). In the theories of economic growth, a set of different concepts are usually used for proximate determinant human capital. The conventional method measures human capital using educational attainment, but because of the shortcomings of this approach the other concepts were introduced in the theories of economic growth, such as: quality of formal education, informal education, health and nutrition, the structure of the labour market, institutions, culture and geography. All those fundamental determinants of human capital are discussed in the following sections. A particular focus is also given to the two key perspectives built in the models of economic growth: accumulation of human capital and stock of human capital as the source of economic growth.

1.1. Quantity and Quality of Formal Education

The most used measures of human capital are the level of educational attainment (percentage of the population aged 25 and over categorized by the attained highest level of education), the average schooling years of the population over 25 years of age (Barro and Lee, 2000) and enrolment rates, i.e. the proportion of adults enrolled in secondary education (Barro, 1991). The simplicity of measuring it and the availability of data on education for different countries are one of the key reasons why many of the researchers reach for this concept of human capital. However, in spite of its evident advantage, this approach lives out several important aspects of education, not to mention other aspects of human capital, such as: the quality of formal education and the relevance of informal education.

Equating years of schooling with human capital is problematic for several reasons. Mulligan and Sala-i-Martin name the following shortcomings of the approach:

• In aggregating heterogeneous workers, it assumes that workers with a given level of attainment are perfect substitutes for workers with any other attainment level, and that the elasticity of substitution across workers of different attainment levels is constant. To take an extreme example, this assumption implies that "in principle a sufficiently large group of university professors could substitute for an Olympic athlete".

• It assumes that each year of schooling increases the productivity of a worker by a constant absolute amount, regardless of the worker's level of schooling. In the aggregate, this means that raising average years of schooling from 0.5 to 1 doubles the stock of human capital just like raising years of schooling from five to ten years. Moreover, if the production function is Cobb-Douglas, output would increase by the same factor in both cases too, which does not seem plausible.

• One year of schooling is assumed to yield the same productivity increase in all fields of study, and in all educational institutions or systems, regardless of their quality (Schuett, 2003).

The quantity of formal education represents an investment cost approach, but the average years of schooling is not the only way to measure the educational aspect of human capital. Pritchett (2001), for example, approximates this variable as the discounted wage premium of education over unskilled labour, and Heckman and Klenow (1997) propose to estimate human capital with a modified Mincer «wage» regression by specifying a linear equation between the stock of human capital and years of schooling (Buesselmann, 2009:5). Another approach, suggested by Blankenau and Simpson (2004), approximates schooling by using public education expenditures (Buesselmann, 2009:5).

Fundamentally, using school attainment as a measure of human capital in an international setting presents enormous difficulties. In comparing human capital across countries, it is necessary to assume that the schools across diverse countries are imparting the same amount of learning per year in all countries. In other words, a year of school in Japan has the same value in terms of skills as a year of school in South Africa. In general, this is implausible. A second problem with this measurement of human capital is that it presumes schooling is the only source of human capital and skills (Hanushek, 2013).

As empirical evidence has been showing, the level of educational attainment is not a perfect measure of human capital accumulation. Moreover, the theories of economic growth should take this into account.

In order to include the quality of formal education in economic growth theories several measures have been proposed: skills, typically measured by achievement tests, and many determinants of skills such as funding system, school resources, teacher recruitment and training, the quality of programs, teaching methods, families, neighbourhoods, peers, general institutional structure, the allocation of resources between different levels of schooling etc. The economics of education has identified following determinants as the drivers of educational attainment (Bagaria, Bottini and Coelho, 2013):

• broad contextual drivers such as the socioeconomic background of a child (e.g. family income and parental education) and their knock-on effect on home learning environment;

• pupil-level factors (e.g. having been in care at some stage, having English as another language (EAL) status, Special Educational Needs (SEN)14 status, mobility and ethnicity); these have a complex relationship with material disadvantage;

• school-level factors that determine the quality of the child's formal learning environment such as teaching, peer composition, resources and the general effectiveness of individual schools in overcoming material barriers.

Recent evidence (Kramarz, Machin and Ouazad, 2009) on the relative contributions of pupils, schools and peers shows that the pupil effect mostly explains the variance of test scores. The standard deviation of pupil effects is between 4 to 5 times larger than the standard deviation of school effects - the second biggest source of variance in the results. Many other studies suggest that families are much more important than schools and peers in explaining the variance in results (Teddlie and Reynolds, 2000; Todd and Wolpin, 2007, as cited in Bagaria, Bottini and Coelho, 2013).

High-quality teaching, as economists of education say, is the key way of improving schools' education outcomes, much more so than extra resources, higher teacher wages or class size reductions. Moreover, dissemination of high-quality teaching through the school system depends fundamentally on school incentives (Bagaria, Bottini and Coelho, 2013):
• Performance measures have consequences for school behaviour. Schools tend to focus on improving the attainment of particular groups of children according to incentives determined by demand and by the regulatory assessment framework;
• There is increasing evidence that school autonomy combined with a strong accountability framework is associated with improved school performance. Giving schools, more freedom might enable them to respond to local circumstances and become more innovative;
• Choice and competition combined with autonomy/accountability creates improved standards. Competition by itself is likely to have small effects, especially for disadvantaged children.

Until recently, comparable data across countries were only available on rates of school enrolment and mean years of schooling. As data on qualitative measures of education have recently become available, several studies have considered, not only the quantity, but also the quality of education (Savvides and Stengos, 2009:7-8), i. e. the skills as key quality indicator assessed through standardized international tests. The fundamental idea is that skills, as measured by achievement, can be used as a direct indicator of the human capital of a country. Empirical evidence (Hanushek and Woessmann, 2012) is showing that only the portion of schooling that is directly related to skills has any impact on cross-country differences in growth (Hanushek, 2013). There are two current sources of assessments: the International Association for the Evaluation of Educational Achievement (IEA) which has produced the TIMSS assessments and related tests; and the Organisation for Economic Cooperation and Development (OECD) which has produced the PISA assessments (Savvides and Stengos, 2009:7-8).

Hanushek and Kimko derived such quality measures using student scores from six international tests in mathematics and science, delivered between 1965 and 1991. They justify their focus on math and science by making reference to recent theories of growth stressing the importance of research and development. Hanushek/Kimko combine all test scores available for individual countries into a single measure of cognitive achievement. The research has shown following results: on the one hand, quality is found to have a

highly significant positive effect on growth and to increase the explanatory power of the regression by more than 30 percentage points; on the other hand, the coefficient on the quantity of education becomes much smaller and loses significance (Schuett, 2003).

Hanushek and Schultz (2012) state that a one standard deviation difference in test performance (100 points on the PISA assessment) is related to a 2 percentage point difference in annual growth rates of gross domestic product per capita (Bagaria, Bottini and Coelho, 2013:15-16).

Educational attainment may not be a good proxy for the skills acquired at school because it measures only the quantity of education while neglecting quality. National education systems are likely to vary considerably in their capacity to impart knowledge and skills. Thus, a year of education may induce quite different increases in students' skills depending on the quality of schooling. Labour economics recognized this issues early enough. In the empirical growth literature, two distinct ways to account for qualitative differences across education systems have been explored: first, including input-oriented indicators of quality (such as educational expenditure per student, student-teacher ratios or teacher salaries) in regressions, and second, including output-oriented, direct measures of skills based on student performance on standardized international tests. There is little support for a robust relationship between educational inputs and a schooling system's output in terms of test performance (Schuett, 2003). It is, therefore, more appropriate to use variables that measure the human capital output rather than the input, as the educational systems can differ considerably with respect to efficiency (Middendorf, 2005:8).

More recently, thanks to the development of new datasets, authors have been able to consider different measures, such as making a distinction between entrepreneurs/managers and worker education (Bloom and Van Reenen, 2007; 2010; La Porta and Shleifer, 2008; Syverson, 2011, as cited in Bagaria, Bottini and Coelho, 2013:15-16).

1.2. Informal education

The formal education approach ignores the role of informal education in the human capital accumulation process, mostly because of the lack of the standardized measure of quantity and quality of such sort of education. However, in measuring human capital, the contribution of the on-the-job training, learning-by-doing and self-learning should not be neglected, and more efforts should be made to create an acceptable measure. For example, Becker (1964) broadened the concept of human capital from that of formal schooling to include additional sources of human capital accumulation such as on-the-job training (both general and explicit on-the-job training), informal gathering of information that enhances a worker's productivity, and other investments to improve "emotional and physical health." He went on to analyse the amount of investment individuals would undertake in training and the rate of return on that investment. Factors that influence the return include uncertainty and the non-liquid nature of the investment, as well as capital market imperfections and differences in abilities and opportunities (Savvides and Stengos, 2009:5). Impact of intangibles on human capital also has to be addressed (Verbić and Polanec, 2014). Problems in measuring human capital in scientometric studies have been investigated in Dragoş, Dinu, Pop and Dabija (2014).

1.3. Health and nutrition

The data on health status and nutrition offer broader and more realistic approach to the proximate determinant human capital. The appropriate health indicators could be public expenditures on health as a percentage of GDP, life expectancy at birth, infant survival rate, and others. To construct more accurate proxy for human capital the combination of education and health indicators could be used, for example a health-adjusted education indicator (enrolment rates at primary level multiplied with the expenditure on health as a percentage of GDP) as used by Qadri and Waheed (2011).

A variety of policies promoted by the World Bank and other development agencies emphasize improving health and nutrition as a way of developing human capital. These efforts reflect a range of analyses of various health issues relative to learning including micro-nutrients (Bloom, Canning, and Jamison (2004)), worms in school children (Miguel and Kremer (2004)), malaria, and other issues. Others have shown a direct connection between health and learning (Gomes-Neto, Hanushek, Leite, and Frota-Bezzera (1997), Bundy (2005), as cited in Hanushek, 2013).

There are several channels that define the contribution of health to production and output. A healthier worker can produce more output than an unhealthy worker because of his higher physical and mental capabilities, vigour and stamina. In the same way, for a given level of all other factors, the economy can produce higher output if it has higher level of healthy workers. Health is a major factor in determining the level of returns from education because a healthier person can learn more than an unhealthy one from a given level of education. In this way, improvement in health increases output due to increased strength and also due to more learning from a given level of education (Qadri and Waheed, 2011:818).

Nutrition has a strong link with productivity, output, and economic growth. A person who intakes nutritious food is likely to be more productive due to high vigour and strength. In this way providing good nutrition, is considered as an investment in human capital. Particularly in the case of economic growth, education and health reinforce each other; being healthy is as important for economic growth as being educated (Taniguchi; Wang 2003, as cited in Qadri and Waheed, 2011:818).

Good health and nutrition enhance workers' productivity. Healthier people who live longer have stronger incentives to invest in developing their skills because they expect to reap the benefits of such investments over longer periods. Better health increases workforce productivity by reducing the incapacity, debility and number of days lost due to sick leave. Moreover, good health helps to forge improved levels of education by increasing levels of schooling and scholastic performance (Schultz, 1997). Health affects economic growth through its impact on demographic factors. Shorter life expectancies inhibit investment in education and other forms of human capital since there is a greater risk that each will not survive long enough to benefit from investment. In addition, a larger proportion of the population which is dependent has a detrimental effect on rates of savings and capital investment and hence on subsequent growth (Kelly and Schmidt, 1996). Healthier workers are more productive for a variety of reasons – increased vigour, strength, attentiveness, stamina, creativity and so forth. Health and malnutrition reduce the physical capacity of the labourer, leading to lower productivity and resulting in lower wages (Zimmer et al., 2000, as cited in Halder and Mallik, 2010:9-10).

When health improves, the country can produce more output with any given combination of skills, physical capital, and technological knowledge. Increases in life expectancy have a direct effect on the steady-state average skill level of the population, by affecting the skill-adjusted death rate that constitutes the effective depreciation rate of aggregate skills, and hence affecting the steady-state level of skills per active worker. The sign of this effect depends on its demographic incidence. If the increase in life expectancy works primarily through prolonging the lifetime of productive workers who have already formed most of their skills, then the skill-adjusted death rate will decrease, leading to an increase in level of skills per active worker. However, if it works primarily through a reduction in infant mortality then the skill-adjusted death rate may increase because the average age of the population will be reduced and the average death will destroy a larger fraction of the existing stock of skills (Howitt, 2005).

Health plays a major role in determining the rate of return to education. Children who are well nourished, vigorous and alert will gain more from a given amount of education that will children who are malnourished and suffering the debilitating effects of disease. This effect shows up as an increase in the learning efficiency parameter.

One of the benefits of good health, especially good childhood health and good maternal health, is that it tends to make a person more creative. Just as a healthier person will be more efficient in producing goods and services, so will the person be more efficient in producing new ideas. In other words, one of the effects that one would expect to come from an improvement in the state of health in a country is an increase in the research efficiency parameter that affects the country's ability to generate innovations. Another benefit of improved childhood health and maternal health is that young people develop a better ability to cope with stress, and hence to adapt to the frequently disruptive and stressful effects of rapid technological change. Empirically there is a high negative correlation between various indicators of population health and measures of income inequality (Howitt, 2005).

1.4. The Structure of the Labour Market

Next to the investment cost approach (the level of educational attainment) another method could be used in measuring human capital. The market value approach focuses on worker productivity, which, according to economic theory, equals the wage rate in equilibrium (Buesselmann, 2009:5). This measure is also called the labour income-based measure of human capital (LIB). The LIB measure, developed by Mulligan and Sala-i-Martin (1997) evaluates productivity according to the wage rate, which should optimally reflect an individual's entire human capital stock (i.e., experience, training, schooling, health, etc.). In order to make the LIB measure more accurate some other authors corrected the wage rate for changes in labour supply and demand, starting from the premise that skill-biased technological change causes the relative demand for skilled workers to shift (Buesselmann, 2009).

Human capital is generated and put into use in labour markets. The structure of the job market is, therefore, critical to the quantity and quality of human capital that is made and for the uses to which it is put. The structure of the market will determine, for example, how much human capital is put into growth-enhancing activities and how much into other activities, such as redistribution. It will also determine what types of human capital will be demanded. Despite the popularity of the recent growth literature, not many labour economists have studied the relation between human capital and growth. Research in growth has become the domain of macroeconomists whose data on labour markets amounts

to two or three aggregate series — usually for employment, schooling, and participation rates. As a result, progress in the integration of labour-market institutions with aggregate growth has been slow. Looking at the data that macroeconomists have available on labour markets, and at the propositions put forward by growth theorists for the link between labour market outcomes and growth, it becomes obvious that not much progress can be made within the current cross-country research agenda. Deeper country research is needed that pays attention to the institutional structure of the country in question and to the links between human capital, the institutional structure and the sources of growth (Pissarides, 2000:8). Human capital impact on unemployment is also important (Tomić, 2014). That is particularly visible in today's construction sector (Vilutienė, Podvezko, Ambrasas and Šarka, 2014). Persistence in the human capital time series is also an issue to consider (Škare and Stjepanović, 2013).

1.5. Institutions, Culture and Geography as Fundamental Determinants

North and Thomas (1973) consider institutions, culture and geography are fundamental determinants of economic growth. Moreover, education, innovation, economies of scale, and capital accumulation are not causes of growth, they are growth (as cited in Acemoglu, Gallego and Robinson, 2014). The lack of the comparable institutional variables is one of the main reasons why the researchers avoid using institutions as a determinant. However, there is some progress in that direction (see for example Acemoglu, Johnson and Robinson, 2004).

Helpman (2004:141) states that future research has to identify the channels through which institutions affect growth and the ways in which various institutions interact. In doing so, the researchers should bear in mind that, as highlighted by Bardhan (2005), macro cross-national studies are not always fitted for giving good insights into the mechanisms and processes of development and underdevelopment. That creates a demand for theory-driven, empirically grounded and policy-relevant small-N studies looking at the interaction between politics, institutions and growth in particular countries. The context-specific analysis of institutions is essential for understanding the sources of credible commitment and self-enforcing institutions (Dellepiane-Avellaneda, 2010).

1.6. Two Perspectives: Accumulation and the Stock of Human Capital as the Source of Economic Growth

In the models of economic growth, there are two different perspectives on the source of economic growth. The first approach has its origin in Becker's (1964) theory of human capital and has attracted attention with the 1988 article by Lucas. It is based on the idea that growth is primarily driven by the accumulation of human capital. According to this approach, differences in growth rates of per capita income across economies are in large part accounted for by differences in the rates at which the economies accumulate human capital. The second approach dates back to the seminal paper of Nelson and Phelps (1966) and has recently been revived in Schumpeterian growth literature. It contends that the stock of human capital determines the economy's capacity to innovate or catch up with more advanced economies, which in turn drives economic growth. Hence, the level of human capital stock is, though indirectly, a determinant of per capita economic growth in this view. In the economy assumed by Lucas (1988), individuals choose at each date how to allocate their time between current production and skills acquisition (or schooling), taking

into account increases in productivity and wages in future periods that arise from current investment of time in education or training (Izushi and Huggins, 2004).

There is disagreement in empirical evidence as to which influences economic growth – accumulation of human capital or level of human capital stock (Izushi and Huggins, 2004:83-85). In contrast to the prediction of the knowledge-based economy, empirical findings show that there is not any significant association between the existing stock of research workers and economic growth. Instead, economic growth is found to be associated with an accumulation of research workers. That suggests that a key to economic growth is a continuous development of high-order human capital (Izushi and Huggins, 2004).

In order to include both perspectives, some studies have included both variables in the analysis – the human capital stock and its rate of accumulation (Middendorf, 2005).

The two perspectives on the source of economic growth are also the key criteria by which usually the theory categorizes models of economic growth. According to the Solow-Swan model, the growth of per capita income arises from the accumulation of capital until the economy reaches a steady state. In the steady state, per capita income growth relies solely on technological progress that the model does not attempt to explain. In contrast, endogenous growth models set R&D at the center of their framework. They predict that income per capita growth is determined by the amount of resources devoted to R&D. The neoclassical Solow-Swan model sees the change in the quantity of capital (i.e. capital accumulation) as the source of economic growth (until the economy reaches a steady state), whereas endogenous growth models assume that the level of the stock of a particular capital (that is devoted to R&D) decides economic growth (Izushi and Huggins, 2004). Those and other distinctions are discussed in the following chapters 3 and 4. Economies with larger human capital stock are more resilient to economic crises (Shakina and Barajas, 2014).

2. Theories of human capital and economic growth with exogenous technical progress

2.1. The Basic Neoclassical Solow-Svan Model

The Solow–Swan model is the primary benchmark against which alternative and more refined models are measured. The model describes a situation where there is zero growth (of per capita income) in equilibrium (steady state) and offers insights into why this is the case and how an economy can achieve alternative steady states characterized by positive growth rates. The main assumptions that underlie the model are: (1) a production function that displays diminishing returns in the factors of production (capital and labour) and admits constant returns to scale, that is, the case where doubling all inputs will double output (or the production function is homogeneous of degree one); and (2) saving by households is a constant proportion of their income. Hence, output is determined from the production side when firms maximize their profits taking as given the constant portion of the output that is saved by households and used for capital accumulation. The model predicts that with diminishing returns there can be no long-run economic growth and the economy will stagnate at its zero growth dynamic equilibrium (Savvides and Stengos, 2009).

Even though the assumptions of the model are quite restrictive, the model itself is very useful in demonstrating the mechanics that allow economies to grow (or stagnate) in the long run. In the framework of the Solow–Swan model, countries with higher savings rates will have a higher per capita income in equilibrium than poorer countries but will have zero

economic growth. The model concludes that there can be no long-run economic growth, even though different economies may differ in terms of their equilibrium per capita income. The reason it fails to produce long-term growth lies in the nature of the neoclassical production function characterized by diminishing returns to its inputs (Savvides and Stengos, 2009).

An obvious limitation of the Solow-Swan model is its failure in accounting for the causes of technological progress. Another issue of the Solow-Swan model is its assumption of constant returns to scale. There is some evidence that suggests increasing returns in long-term economic growth (Izushi and Huggins, 2004:78-79)

The Solow-Swan model also misses important points about human capital such as rent-seeking activities.

2.2. Human Capital-Extended Sollow-Svan Model (Mankiw, Romer and Weil, 1992)

The extended model assumes that the aggregate output function includes three inputs: physical capital, human capital, and labour measured in efficiency units. In the Mankiw, Romer, and Weil framework, human capital contributes directly to production. The production function exhibits constant returns to scale in the three inputs but diminishing returns in the reproducible inputs (physical and human capital).

2.3. The Cass-Koopmans-Ramsey Model

One of the main simplifying assumptions of the Solow–Swan model is a constant savings rate. However, it is more plausible to assume that the savings rate is not constant but is determined endogenously through the optimizing behaviour of households. In this context, households choose their lifetime consumption (and savings) by maximizing their utility subject to a lifetime budget constraint. Firms, on the other hand, determine the levels of capital and labour they use in producing output in order to maximize profits. This framework has become known as the Cass–Koopmans–Ramsey (CKR) model after the work of Ramsey (1928) that was followed by Cass (1965) and Koopmans (1965). This model arrives at a Pareto optimal decentralized equilibrium since a social planner maximizing social welfare would arrive at the same equilibrium outcome. In this context, a social planner is a fictional character who possesses all the powers to achieve the best possible outcome for all members of the society. If a decentralized economy attains the same equilibrium, then the decentralized economy achieves Pareto optimality because it is not possible to improve the welfare of a single person without reducing the welfare of someone else. If there is a divergence between the equilibrium outcomes achieved by a social planner and the decentralized economy, the latter does not attain a Pareto optimal solution and there is room for intervention by a policy-making authority to improve welfare (Savvides and Stengos, 2009).

One of the main findings of the CKR model vis-à-vis the Solow–Swan model with a constant savings rate is that the optimal capital–labour ratio will be higher in the latter case. That is to be expected because households in a CKR environment save less than what they would in the Solow–Swan model. That is happening because future consumption does not yield the same utility as present consumption due to the presence of a discount factor. This calls for less "sacrifice" in terms of foregone consumption and consequently less savings and a lower level for the equilibrium level of per capita income and capital–labour ratio than in the Solow–Swan model with a constant savings rate (Savvides and Stengos, 2009).

The difference between the two setups is in a CKR environment the optimal level of per capita output in long-run equilibrium will be lower than that in a Solow–Swan environment. That is due to the discount factor that penalizes future consumption and produces lower savings and consequently less capital accumulation relative to the case of constant savings. However, an important characteristic of the decentralized economy described by the CKR model is that it is Pareto optimal (Savvides and Stengos, 2009).

2.4. The AK Model (Frankel-Romer model)

An alternative and one might say, unsophisticated way to get around the issue of diminishing returns is to assume a production function that is not subject to diminishing returns. That is what the so-called AK model does by assuming that output is a linear function of physical capital. Constant proportions production function is an observation borne by the evidence for developed countries where the ratio of capital to output is constant and approximately equal to three, in the long run. An economy that is characterized by such a production function will accumulate physical capital continuously without experiencing diminishing returns. An implication of this model, however, is that economies that differ in their initial conditions (different initial capital–labour ratio) will grow at different rates indefinitely and will never converge (Savvides and Stengos, 2009).

AK models of economic growth assume that diminishing returns to capital are counteracted by growth in other variables so that production does not encounter diminishing returns (Savvides and Stengos, 2009).

3. Theories of human capital and endogenous economic growth - human capital externalities

3.1. Human Capital and Productivity (Lucas, 1988)

Lucas assumes that individuals invest in human capital by spending part of their time acquiring skills, instead of a fraction of their income, like in Mankiw/Romer/Weil (1992). Besides, Lucas ignores depreciation of human capital. More importantly, and contrary to Mankiw/Romer/Weil, in the Lucas model, there are two sectors of production: one for consumption goods and physical capital, and another for human capital. The only input in the production of human capital is human capital meaning education "relies heavily on educated people as an input". Above all, the Lucas model is characterized by self-sustained growth, which is driven by the accumulation of human capital. If, for some reason, the equilibrium value of 1-u (the time spent acquiring skills) were to rise, this would lead to a permanent increase of growth. Therefore, additional skill acquisition has a rate effect in the Lucas model, as opposed to the augmented Solow model, where (permanently) higher human capital accumulation only causes a level effect (Schuett, 2003:12).

Although the existence of spillovers from human capital is not a necessary condition for sustained growth in this model (what is actually responsible is the fact that there are constant returns to human capital production), the question of whether or not there are externalities to the average level of skills in the workforce is clearly of significance. One example of positive human capital externalities may be social benefits such as crime reduction. Lucas himself offers an alternative explanation and presents some general observations that support the existence of positive externalities. He points out that in the arts and sciences (the "creative professions"), the interaction between colleagues has

significant benefits and will often prove stimulating for their intellectual output. Moreover, he argues "economic life is creative in much the same way." According to Lucas, there are two facts that can be interpreted as primarily supportive of this view: immigration and the existence of cities. First, if there were no externalities to human capital, it would offer the highest returns in countries where it was in scarce supply. Thus, one would expect to observe migration of skilled workers from rich to poor countries, instead of the observed flows in the opposite direction. Second, without external effects, there is no reason for cities to exist: capital and labour could just as well move to the countryside, where the rental price of land is much lower. The prospect of revealing evidence confirming the existence of human capital externalities has been one of the primary motivations for the empirical macroeconomic literature looking at the importance of human capital for growth (Schuett, 2003:11-12).

3.2. Human Capital and Technological Diffusion (Nelson and Phelps, 1966, Benhabib and Spiegel, 1996)

In their seminal contribution, Nelson and Phelps (1966) distinguish between two types of jobs: those that are "routinized" and those that require "adaptation" to change. Their central hypothesis is that productive activity requires adaptation to change, and more educated workers are more prone to introduce new techniques. Education makes people more likely to innovate and "speeds the process of technological diffusion".

In summary, the Benhabib–Spiegel model views the country with the leading technology level as the "locomotive" that provides the engine by which other countries catch up to the leader; asymptotically all countries grow at the same rate (but as they point out, the transition period may be "extremely" long). While the level of human capital is positively related to the growth of total factor productivity, they caution that the effect may be masked empirically unless one controls for the catch-up effect. Countries with low levels of technology and human capital may grow faster than the leader because the catch-up effect may dominate, while countries similar to the leader (in terms of the level of productivity and human capital) may grow more slowly than the leader if the catch-up effect is insignificant compared to the endogenous growth effect (Barro).

3.3. Human Capital and Innovations (Romer, 1990) or Schumpeterian Growth Model

Romer (1990, as cited in Izushi and Huggins, 2004) notes that research and development is carried out by educated workers and concludes that a greater stock of human capital will lead to higher economic growth by virtue of its innovation-promoting effects. A portion of human capital is used in the production of final goods (similar to the Lucas model) but the remainder is employed in R&D activities. The Romer model, however, does not need to rely on externalities in the intertemporal accumulation of human capital (as in the Lucas model) to generate sustained per capita income growth, and does not treat human capital as a non-excludable good (as do Benhabib and Spiegel).

Aghion and Howitt (1998) extended the model to include more than one economic sector and to consider technology spillovers across sectors. They also introduced the uncertain nature of innovation in their model. According to them the creation of innovations through research is a stochastic process in which the innovation quantity is expressed as flow probability (Izushi and Huggins, 2004).

Aghion and Howitt (1998) also incorporated in their model horizontal imitation as a source to restrict effects of increasing returns to scale. While the neoclassical theory of Solow and Swan assumes constant returns to scale, R&D models of growth no longer have constant returns in all the factors that are growing: capital, knowledge and labour. Growth models proposed by Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992), for example, predict that the steady-state growth rate depends on the level of resources devoted to R&D – if the degree of R&D resources is doubled, then per capita growth in output should also double. Jones (1995) criticizes this, showing the dramatic increase of scientists and engineers in the US during the last 40 years contradicting a constant mean of the growth rate of the economy over the same period. To counter this, Aghion and Howitt argue that a source that limits such scale effects is imitations and a resultant growth of intermediate goods in the economy without adding to overall productivity. Given the same level of leading-edge technology, the growth rate depends positively upon research input. Further, as an effect of horizontal imitation, Aghion and Howitt argue that the steady-state growth rate of per-worker income also depends positively on population growth (Izushi and Huggins, 2004).

3.4. Human Capital and Fertility (Becker, Murphy and Tamura, 1990)

In the standard neoclassical growth model, a higher rate of population growth reduces the steady-state value of capital per worker and thereby lowers the steady-state value of per capita income. The decrease in per capita income implies that the economy grows in the transition (for a given value) at a slower rate. The rate of population growth is exogenous in this model, and the effect on the steady-state level of capital per worker involves the flow of new capital that has to be provided to accompany the flow of new workers.

Richer theories, such as the one by Becker, Murphy, and Tamura (1990), include the resources expended on children and allow fertility to be a choice variable of families. A key result is that a larger stock of human capital per person raises the wage rate and, therefore, the time cost of raising children. (The assumption is that the productivity in the sector that raises children does not rise as fast as that in the sectors that produce goods and new human capital.) A higher stock of human capital motivates families to choose a lower fertility rate and to raise the investment in human capital for each child (that is, to substitute quality for quantity in children). These responses of population growth and human capital investment tend to raise the growth rate of output. The model, therefore, provides another channel through which a larger stock of human capital results in a higher subsequent rate of economic growth (Barro).

3.5. Human Capital, Young Adult Mortality and Infant Mortality (Tamura, 2004)

Tamura (2004) has developed a general equilibrium model of fertility and human capital investment with young adult mortality. Parents maximize expected utility producing a precautionary demand for children. Because young adult mortality is negatively related to average young adult human capital, human capital accumulation lowers mortality, inducing a demographic transition and an industrial revolution. Data confirm the model prediction that young adult mortality affects human capital investments. The model prediction of a positive relationship between infant mortality and young adult mortality is confirmed. Further, the data indicate a negative correlation between total factor productivity growth and accumulation of schooling. The model fits the data on world and country populations, per capita incomes, age at entry into the labour force, total fertility rates, infant mortality,

life expectancy, and conditional life expectancy. When young adult mortality is a function of the average human capital of young women in the population, human capital accumulation produces a Demographic Transition to an Industrial Revolution. The model assumes that individuals maximize expected discounted dynastic utility. Although preferences are logarithmic, expected utility maximization provides a precautionary demand for children. Therefore in high young adult mortality environments fertility is high and human capital investments are small. Human capital accumulation eventually lowers young adult mortality. Falling young adult mortality produces falling fertility. Lower levels of fertility reduce the cost of human capital investments, and hence the rate of human capital accumulation accelerates. The model predicts that human capital investment should be negatively related to young adult mortality, but independent of infant mortality. The first prediction is confirmed, but the second is not. The model's prediction that total fertility rates should be positively related to young adult mortality and infant mortality is also consistent with the data. The model was calibrated to fit the world population experience from 25,000 BC to 2000 AD and the prosperous global population from 1 AD to 2000 AD. The zero mean unexpected young adult mortality shocks were chosen to fit both the population histories of the rich and poor regions. The model was also calibrated to fit the infant mortality and life expectation series of the rich countries. With these choices, the model was able to fit the behaviour of 22 rich countries, and 6 poor regions. This behaviour includes population, total fertility rates, infant mortality rates, life expectancy at birth, conditional life expectancy, age at entry into the labour force and income. These individual series are matched well by the model solutions both at the world level and at the disaggregated regional level.

To conclude this paper section a comparative review of three different growth models that include human capital is given in the table 1.

4. The problem of reverse causation

Many theoretical and empirical papers on economic growth have raised a question about the direction of causality between economic growth and human capital.

For example, Bils/Klenow pick up this theme in the context of the growth-and-schooling debate. The possibility of a feedback effect from a country's level of income to its demand for schooling is rather obvious (education being not only an investment but also a consumption good), so that an equation with the level of per capita output as dependent variable will almost certainly overestimate the coefficient on education. However, Bils/Klenow identify another channel through which the (anticipated) growth rate may affect the demand for schooling, and, therefore, induce reverse causation bias in growth equations too. In their model, the return to schooling is a positive function of future rates of economic growth because higher growth has a favourable effect on wages. Hence, individuals will demand more education if they anticipate faster output growth (Schuett, 2013).

Table no. 1: Differences between models of economic growth that include human capital

	Augmented *Solow* model	***Lucas* model**	***Romer* model**
Human capital is accumulated by…	investing a fraction of income	spending a fraction of the time acquiring skills	not modeled
Technology for production of human capital	same production function for C, K, and H	separate sector for production of H using only human capital	not modeled
Role of human capital	input in the production	input in the production of Y and H	input in the production of Y and A
Growth rate determined…	outside of the model	within the model	within the model
Determinants of long-run growth	Exogenous technological change	rate of human capital accumulation	stock of human capital
Effect of a permanent change in the variable governing the accumulation of human capital	level effect (relevant variable: *sH*)	rate effect (relevant variable: 1-u*)	rate effect (though not explicitly modeled)
Effect of a one-off increase in the stock of human capital	level effect	level effect	rate effect

Source: Schuett, 2013:15.

Bils/Klenow use a Mincerian measure of human capital and calibrate a model of growth with parameter values chosen mostly to reflect microeconomic estimates. Their analysis reveals that no more than 30 percent of the empirical correlation between initial (= 1960) school enrolment rates and subsequent economic growth can be attributed to a causal effect of schooling on growth. They go on to test the reverse causality channel, where they make the assumption that individuals anticipate between a quarter and one-half of the deviation of their country's growth rate from the world average. Bils/Klenow find that, depending on the choice of parameter values, reverse causation can explain between 33 and 100 percent of the observed correlation between growth and enrolment. Of course, in the latter case, there would be no effect at all of schooling on growth, all of the empirical relationship being due to reverse causation. They concede, however, that their results are subject to the qualification that the high value that they assume for the elasticity of the demand for schooling with respect to the return to education is out of line with microeconomic estimates (Schuett, 2013).

In addition, the fact that Bils/Klenow concentrate on school enrolment rates leaves open the question of how much of a concern reverse causality is for studies using measures of educational attainment, rather than enrolment. If the period over which differences are calculated is long enough for changes in enrolment to propagate through the labour force (thereby affecting the economy's human capital stock), the issue of reverse causality can certainly not be ignored (Schuett, 2013).

The flip side of this argument gives reason to be more optimistic, however. De la Fuente/Ciccone and Temple point out that if growth rates or differences are computed over short periods, reverse causation bias is probably negligible (Schuett, 2013).

5. Empirical studies on human capital and economic growth

Empirical research on human capital and economic growth is vast. This paper's aim is not to include all the available research but to give insight into different approaches, focuses and methods used in that field area.

5.1. Empirical Studies by the Used Methods

The empirical studies that use statistical data from a cross section of countries and employ econometric estimation techniques could be differentiated by the specification of the estimating equation, the way human capital is defined, the time frame considered, and the countries included in the sample (Savvides and Stengos, 2009:107). Following empirical studies' approaches can be identified: cross-country growth regression approach, cross-country growth accounting approach, calibration and simulation methods approach and qualitative methods approach (the classification is based on Savvides and Stengos, 2009).

5.1.1. Cross-Country Growth Regression Approach

The cross-country growth regression approach centers on explaining economic growth as a function of the initial level of output per worker and variables that determine an economy's steady-state level of output per worker (e.g., Barro 1997; Barro and Sala-i-Martin 2004). Steady-state level of output per worker depends on country characteristics over which economic policy may or may not have an influence. One important feature is a country's level of human capital (Savvides and Stengos, 2009:119).

5.1.2. Cross-Country Growth Accounting Approach

The growth accounting methodology divides the growth of output into the weighted growth of inputs and a residual (Savvides and Stengos, 2009:127).

Benhabib and Spiegel (1994), for example, estimated a general production function in three inputs (physical and human capital and labour) in the log–difference form. Their measure of human capital stock was mean years of schooling of the working age population. Their cross-section results showed that the estimate of change in (the log) mean years of education was an insignificant determinant of the growth of output. This result was invariant to alternatives that considered different sources of data for human capital, the inclusion of additional explanatory variables or different country samples. This led them to propose that the role of human capital is not as a direct input to production but as a determinant of TFP (total factor productivity) growth (Savvides and Stengos, 2009:127).

5.1.3. Calibration and Simulation Methods Approach

Some empirical work in the human capital – economic growth field is conducted by the use of calibration and simulation methods approach. For example, Altăr, Necula and Bobeică (2008) have modelled the economic growth in Romania, with the particular focus on the role of human capital in a following way: they simulate possible growth paths assuming that the Romanian economy behaves according to the hypothesis of the Uzawa-Lucas model. By calibrating the model to the Romanian economy, they were able to forecast the

evolution of the Romanian GDP and the proportion of human capital that will be used in the production of goods and services. Although the population growth rate is considered to be zero, the average real GDP growth rate is around 6% due to the human capital accumulation, which improves the quality of labour.

The model is calibrated by minimizing the distance between the simulated and actual paths for real GDP and fraction of human capital used in the production sector. The calibrated model provides a good approximation for the evolution of the Romanian economy both in-sample (2000:Q1-2005:Q4) and out-of-sample (2006:Q1 2007:Q4). In order to reflect the qualitative effect of labour on economic growth exclusively, the population growth rate is set to zero. The simulations performed for the period 2008-2020 using the calibrated model show that on the long run the real GDP annual growth rate is about 6%, which is consistent with the results of similar studies using other methods (Caraiani, 2008; Pauna, Ghizdeanu, Scutaru et al., 2008). The results also indicate that, in the long run, the human capital will be used in proportion of 46.6% in the production sector. The simulated transitional path is similar to the actual one for the period 2000:Q1-2007:Q4, computed by the methodology in Gong, Greiner and Semmler (2002).

5.1.4. Qualitative Methods Approach

Discussion about the appropriateness of readily available measures/indicators of human capital has led to the use of the qualitative approach to human capital measurement and the analysis of its contribution to the economic growth.

For example, since 1990, United Nations Development Programme (UNDP) has reported Human Development Index (HDI) investigating most of the countries, measuring a country's human development and well-being (http://hdr.undp.org/en/statistics/indices/hid). The structure of the index is constituted to health, knowledge, and standard living with many sub-variables such as life expectancy at birth, adult literacy rate, gross enrolment ratio, and GDP per capita. Considering that the HDI index includes quality aspects, the approach of HDI focuses on all of the individuals' life quality and economic situation. Furthermore, International Labour Office (ILO) tends to utilize the similar index considering the quality aspects such as the Key Indicators of the Labour Market, KILM (Dae-Bong, 2009).

Therefore, it is necessary that the advanced measurement of human capital consider the concept of 'human development', assuming that the notion of development includes both of quantitative growth and qualitative progress. The idea of human development, demands that the new approach of human capital measurement need to pay more attention to social capital. The accumulation of one's human capital is easily performed through social capital. Someone's level of knowledge and skills can be more improved by the networking of family, colleagues, social and constituents rather than isolated situation (Coleman, 1988). This assumption can provide an important clue in terms of understanding how human capital can play a role in social progress (Dae-Bong, 2009).

Finally, it is necessary that the new approach of human capital measurement clarify what indicators can be considered to measure more accurate human capital precisely. It is likely that the conventional analysis of human capital utilizes proxies such as an individual's productivity. OECD presents that the measurement of human capital is closely linked to education-related factors such as high-level qualification, graduation and enrolment rates,

time invested in education, and investment in education in the perspective of the human capital investment as well (Hansson, 2008, as cited in Dae-Bong, 2009:9-10).

5.2. Empirical Studies by Econometric Specification

5.2.1. Studies Based on Convergence Equations

The studies based on convergence equations estimate an equation that is based on the assumption of conditional convergence, as predicted by neoclassical growth models. This specification relates the rate of economic growth to the initial level of output – with the expectation that countries that start from low levels of income should grow faster – and other variables intended to control for the determinants of the steady state. In the table 2 a summary of findings of studies based on convergence equations is given.

Table no. 2: Methodology and findings of studies based on convergence equations

	Specification and period(s) studied	Human capital proxy	Coefficient on the initial stock of human capital[1]	Coefficient on change of (or investment in) human capital[1]
Romer (1989)	single cross-section (1960-1985)	literacy rate	positive (significant)	sign not reported (insignificant)
Barro (1991)	single cross-section (1960-1985)	school-enrollment rate	positive (significant)	not included[2]
Barro and Lee (1994)	pooled (1965-1975, 1975-1985)	years of schooling (from Barro and Lee (1993))	positive (significant) for male secondary[3]	positive (significant) for male secondary[3]
Barro and Sala-i-Martin (1995)	pooled (1965-1975, 1975-1985)	years of schooling (from Barro and Lee (1993))	positive (significant) for male secondary and higher[4]	positive (insignificant) for male secondary and higher[5]
Barro (1998)	pooled (1965-1975, 1975-1985, 1985-1995)	years of schooling (from Barro and Lee (1993))	positive (significant) for male secondary and higher[6]	not included / not reported
Mankiw, Romer and Weil (1992)	single cross-section (1960-1985)	school-enrollment rate	not included[2]	positive (significant)
Gemmell (1996)	single cross-section (1960-1985)	own measure of attainment constructed using enrollment rates	positive (significant)	positive (significant)
Islam (1995)	panel (5-year periods between 1960-1985)	years of schooling (from Barro and Lee (1993))	negative (significant)[7]	not included
Caselli, Esquivel, and Lefort (1996)	panel (5-year periods between 1960-1985)	school-enrollment rate	not included	negative (significant)

Source: Schuett, 2003:27.

Notes:
1) Reported findings apply to the largest sample for which equations have been estimated. Statistical significance based on t-values judged against a 95% confidence level.
2) Barro (1991) and Mankiw, Romer and Weil (1992) both use school-enrolment rates, but interpret them in different ways: as stocks in the former, and as investment rates in the latter.
3) Barro and Lee (1994) report a significantly negative coefficient on female secondary schooling. All other schooling variables are insignificant.
4) Barro and Sala-i-Martin (1995) report negative coefficients on female secondary and higher schooling (insignificant for the former, significant for the latter).
5) Barro and Sala-i-Martin (1995) report insignificant negative coefficients on female secondary and higher schooling.
6) Barro (1998) combines secondary and higher schooling in a single measure. He reports insignificant negative coefficients on the female schooling variable.
7) Islam (1995) does not use beginning-of-the-period levels of schooling, but end-of-the-period levels that are intended to proxy for the steady-state value of human capital.

5.2.2. Studies Estimating an Aggregate Production Function

Aggregate production function derives from the conventional growth accounting approach which analyses the growth experience of a particular country by decomposing the growth rate of output into growth in inputs and (residual) total factor productivity (TFP). The difference is that, in this case, the analysis relates to a cross-section of countries. It has correspondingly sometimes been labelled cross-country growth accounting (Schuett, 2003).

Benhabib and Spiegel were among the first to implement this cross-country growth accounting approach to studying the role of human capital. In their influential paper, they use various measures of the physical capital stock constructed from observed investment flows and estimates of initial capital-output ratios (their results reportedly not being sensitive to the choice of alternative measures). Their preferred human capital proxy is derived through a procedure in which the educational attainment of the labour force is first regressed on enrolment rates for a sample of countries for which both are available. The relationship thus found is then extrapolated to a larger sample for which only school-enrolment ratios are available (Schuett, 2003).

In analysing the contribution of human capital, i.e. education as its key indicator, Pritchett (as cited in Schuett, 2003) has elaborated a problem that he calls a "micro-macro paradox." Although the microeconomic literature finds consistent evidence of substantial private returns to education in the form of higher wages, macroeconomic studies are unable to come up with proof that growth in education spurs income growth. He goes on to present some interesting explanations with the potential to reconcile these apparently conflicting observations:

"Where has all the education gone? I do not propose a single answer, but put forward three possibilities that could account for the results:
   • The newly created educational capital has gone into piracy; that is, privately remunerative but socially unproductive activities.
   • There has been slow growth in the demand for educated labour, so the supply of educational capital has outstripped demand and returns to schooling have declined rapidly.
   • The education system has failed, so a year of schooling provides few (or no) skills."

The first possibility refers to rent-seeking and other distortions in the economy. The third possibility is compatible with a signalling model of wages in the spirit of Spence, where

schooling creates no skills but still leads to higher wages by signalling qualities like ambition or innate ability to the employer (because individuals with those qualities may find it easier to obtain a degree).

5.2.3. Studies Focusing on Data Quality

Some empirical studies' goal has been to improve the quality of the data, and use more sophisticated econometric techniques while hanging onto the conventional measures of human capital (mostly years of educational attainment).

Overall, those studies tend to confirm the hypothesis that data quality matters, i.e. their primary concern is the measurement error. The main implication of this is that deficiencies in older data sets on educational attainment may have led to a downward bias of the estimated coefficients on schooling variables in studies relying on those older data (Schuett, 2003).

5.3. Empirical Studies by the Focus of the Research

More recent empirical studies have focused specifically on the following topics: the role of sex differences, the quality of human capital, and international diffusion of R&D as human capital' externality. The availability of data sets in the recent period has fostered the researchers to reach for and analyse those new measures of human capital.

5.3.1. The Role of Sex Differences

Several studies have investigated whether the impact of human capital on growth differs by sex. The most common method is to introduce two separate explanatory variables for human capital (male and female) and to test for a significantly differential effect on growth. All contributions in this area, however, maintain the linearity assumption between different types of human capital and growth.

A series of papers (e.g., Barro and Lee 1994; Barro 1997, 2001; Barro and Sala-i-Martin 2004) finds a significantly different growth effect for male and female education at the post-primary level measured by mean years of secondary plus tertiary schooling. More importantly, the general conclusion from these studies is that the impact of post-primary male education on growth is positive and significant whereas that for female education is negative and meaningful. One possible explanation for these findings, according to Barro (2001), is that "many countries follow discriminatory practices that prevent the efficient exploitation of well-educated females in the formal labour market" (p. 15). When it comes to education at the primary level, the results are ambiguous. Male schooling at the primary level is generally an insignificant determinant of growth; on the other hand, a significant contribution to female education at the primary level depends on whether fertility is held constant or not (Savvides and Stengos, 2009:135-136).

5.3.2. Quality of Human Capital

In practice, as stated in section 2.1., there are two possibilities for arriving at a measure of the quality of human capital: school inputs (e.g., teacher salaries, expenditures on schools, and pupil–teacher ratios) and scores on internationally standardized tests of cognitive skills (science, mathematics, and reading). Researchers have tended to focus on test scores as a more comprehensive measure of the quality of human capital insofar as they capture improvements that arise, not only from formal education, but also outside of formal schooling. Lee and Barro (2001) discussed the nature of test score data as an indicator of

the quality of human capital and focused on the determinants of differences in test scores across countries. They divided the determinants into two categories: family factors (income and quantity of schooling) and school inputs (pupil–teacher ratio, average teacher salary, educational expenditure per student, and length of school year). They found that both categories were significant determinants of test scores: family factors, as measured by income and education of parents, and resources (inputs) into education, as measured by the pupil–teacher ratio. Two other measures of resources (teacher salary and length of the school year) were not as significant determinants of test scores while the estimate for educational expenditures per pupil was insignificant. They also found that parental income and length of the school year have differential effects on the three test scores, science, mathematics and reading (Savvides and Stengos, 2009: 138-139).

Science scores had a positive and significant effect on growth and, in terms of magnitude, its effect was more important than educational quantity. Mathematics scores were also a major determinant of growth and the extent of this effect was larger than science scores. Finally, reading scores were an insignificant determinant. Given that scores on all three tests were available for only a handful of countries, Barro created an overall rating indicator by combining science scores with reading scores and using the latter to fill in missing observations. The effect of the combined test score on growth was positive and significant while the quantity of education was no longer an important determinant of growth. (Savvides and Stengos, 2009:139)

5.3.3. Human Capital and International Diffusion of Research and Development

There exists a substantial literature concerned with whether research and development (R&D) carried out in relatively advanced economies benefits not only the countries conducting R&D, but also other nations, known as the international diffusion of R&D. One of the issues tackled by the international diffusion literature is the mechanism by which R&D diffuses across international borders. Several studies have shown empirically that human capital (measured by the quantity of schooling) is an important factor that facilitates the international diffusion of R&D. In some ways, this literature parallels and complements the literature on human capital and technological diffusion pioneered by Nelson and Phelps and Benhabib and Spiegel. One significant difference, however, is that the central question addressed in this literature is whether R&D spills across international frontiers and has beneficial effects on the growth of productivity of non-R&D-performing countries (Savvides and Stengos, 2009).

The central issue is whether a measure of a country's "foreign" R&D (R&D carried out by its economic partners with potential spillover benefits) has a positive effect on the growth of domestic TFP. A country's foreign R&D is computed as a weighted average of resources devoted to R&D by the leading industrial countries. The weights used to calculate this measure are meant to capture links between the domestic economy and the foreign countries conducting R&D. These weights have been a matter of considerable debate. Some authors have used bilateral trade shares (either aggregate trade or trade in specific categories such as capital goods), others have used bilateral foreign direct investment (FDI) shares, while others have used the bilateral geographic distance. In addition to international R&D, this literature has introduced human capital (measured by schooling achievement) as an independent determinant of TFP growth and also interacted it with the measure of foreign R&D. The interaction term is meant to test the role of human capital as a facilitator of the diffusion of R&D globally (Savvides and Stengos, 2009:144).

5.4. Regional Studies

The high number of cross-country studies is based on the regional analysis. In this context a typical study includes the following regions, i.e. group of countries, as a research sample: European Union (see for example Izushi and Huggins, 2004; Wilson and Briscoe, 2004; Ederer, 2006; Ederer et al., 2007, Ramos et al., 2009, Tiruneh and Radvansky, 2011), OECD countries (as in Bassanini and Scarpetta, 2001; Buysse, 2002; Engelbrecht, 2003; Middendorf, 2005; Pourshahabi, Mahmoudinia and Soderjani, 2011; Wozniak and Jablonski, 2012), developing countries grouped by the Continent: Middle East and North Africa (as in Pissarides and Veganzones-Varoudakis, 2005; Brach, 2008; Ncube, Anyanwu and Hausken, 2013), Sub-Saharan Africa (see for example in Gyimah-Brempong and Wilson, 2004; Mobolaji Hakeem, 2010; Danquah, Ouattara and Speight, 2010), Latin America and the Caribbean (as in Baris, 2007; Garcia-Fuentes and Kennedy, 2009;), Asia and the Pacific (see for example in Mason and Lee, 2011; Dobson, ed., 2013).

5.5. National Studies

National empirical studies derive their inputs from cross-country studies or focus more on the qualitative determinants of human capital. Some interesting examples would be studies on China (Fleisher, Haizheng and Qiang Zhao, 2010; Whalley and Zhao, 2010; Heckman and Yi, 2012), India (Ojha and Pradhan, 2006; Viswanath, Reddy and Pandit, 2009; Halder and Mallik, 2010; Karimzadeh and Karimzadeh, 2013), USA (Ehrlich, 2007; Aghion, Boustan and Hoxby, 2009; Turner, Tamura and Mulholand, 2013), and Finland (Pelkonen and Ylonen, 1998, Kokkinen, 2008, Kokkinen, 2012).

Conclusion

This research work has shown the attempts of different authors who are looking for the appropriate human capital proxy. In doing so, they usually use the investment cost approach (quantity of education) or market value approach (labour income-based measure of human capital). In recent years, a greater attention is given to the qualitative determinants of human capital such as the quality of formal education, informal education, health and nutrition, institutional structure and others. The new quality indicators, such as skills assessed through international standardized test, have significantly improved the research work on the qualitative aspect of human capital.

Different models of economic growth start from different premises about the source of economic growth. Some of them are based on the idea that growth is primarily driven by the accumulation of human capital, and other see the level of human capital stock as a key growth' driver. Some studies include both variables in the analysis. However, what is common to all of them is the acknowledgment of a significant contribution of human capital to the economic growth, directly or indirectly. More recent theories have developed different models that deal with the human capital externalities, such as technological diffusion, innovations, fertility, young adult mortality and infant mortality. The problem of reverse causation has also been tackled in the analysis of the papers' topic.

Empirical studies on human capital and economic growth show use of different methods, different human capital proxy, and are also differing by the focus of the research and the scope of the study (number of countries included in the sample). The review of the empirical studies follows the theoretical models presented in previous chapters. Cross-country studies are heavily dependent on the availability of data, and national studies give

the researchers an excellent opportunity to search for deeper context-specific analysis of human capital and economic growth.

This paper has stressed the need for the continuous work on the development and implementation of new human capital measures. It should be a common task in which different actors could be engaged: scientists, business representatives, educational institutions, government bodies, professional associations, statistical organizations or departments, media, and others.

The cross-country studies offer a valuable comparable insight into the contributions of human capital to the economic growth. National studies give more room to focus on the analysis of institutional framework, and relations between the development (quality) of institutions and economic growth, as well as inter-institutional relations in shaping human capital proxy determinant.

The paper is an excellent reference point for educational researchers and practitioners as well as for macroeconomists who deal with the causes of economic growth. It is also an invitation for labour economists and microeconomists to engage more in the analysis of human capital – economic growth relations.

This review essay gives a thorough summary of the available theoretical and empirical research on the topic and could be used as a valuable source for future empirical work: cross-country or national studies which will focus on measuring the contributions of human capital to the economic growth, by using both quantitative as well as qualitative determinants of human capital.

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