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HOW TO MEASURE HUMAN CAPITAL: A SHORT REVIEW

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Abstract

This paper focuses on the most important estimation approaches of human capital. These approaches can be labeled as either monetary or non-monetary methods of estimation. The three major monetary methods of human capital are the prospective method, the retrospective method and the integrated approach. The income-based approach (prospective method) estimates human capital based on the present value of a person's future income stream. The cost-based approach (retrospective method) is centered on the "production" costs of human capital, trying to determine the costs of producing human capital by adding up the education and schooling costs. The integrated approach is a mixture of the prospective and retrospective method. On the other side, the non-monetary measures are essentially education-based indicators, such as the literacy rate, the school enrollment rate or the average years of education.

INTRODUCTION

The concept of human capital is a very old one. The source of human capital as a scientific idea can be traced back to Adam Smith (1776). Additionally, starting from the end of the 17th century, there have been numerous interests in calculating the monetary value of human beings. Among the first authors who have made these kinds of calculations it is worth mentioning William Petty (1690), William Farr (1853), Theodor Wittstein (1867), Ernst Engel (1883), Alfred de Foville (1905), Alfred Alphonse Barriol (1908) or Dublin and Lotka (1930).

The modern system of human capital theory has been formed around the 1960's by Jacob Mincer (1958), Theodore W. Schultz (1961) and Gary S. Becker (1962; 1964). Clarifications of the notions of human capital respectively the first pieces of empirical evidence have appeared during this period of time. Among more recent scientists who have dealt with the theory of human capital it is worth mentioning W.A. Lewis, Simon Kuznets or Douglass North. Hence, the modern theory of human capital is approximately 50 years old.

This paper focuses particularly on education as a tool of human capital accumulation. Several studies from the '70s emphasize the major role of education when trying to discover the effects of human capital investments (Lazăr, 2005: 21). Moreover, Schultz (1971) considers education as the "*main source*" of economic growth, whereas Blaug (1976) refers to it as the "*strong heart*" of the human capital theory.

Therefore, this focus on education seems justified given that education increases individuals' ability to learn during their lifetimes and to live healthier lives. Educational capital consists of skills acquired by a person through participation in formal educational systems, of knowledge certified through various diplomas or certificates, or skills acquired outside the formal educational system (Popescu and Pohoaţă, 2007: 18).

The intangibility of the human capital is obvious from its definitions. Goode (1959: 148) links the lack of statistical data on human capital from the 1953 Statistical Yearbook of the United Nations (UN) precisely to its measurement difficulties. Thus, estimations have to be constructed in an indirect way, exactly because of these measurement inconveniences.

The literature distinguishes between examinations of the stock of human capital and of the investments made in it. The stock of human capital reflects the size or level of human capital in a given moment (*stock* variable). On the other hand, the investments in human capital indicate the accumulation of human capital in a certain period of time (*flow* variable). Moreover, the micro analyses concentrate on individual decisions and their effects, while macro analyses stress the role and importance of human capital on economic growth (Kiss, 2012: 65).

The role human capital plays in the process of economic growth can be seen in two ways. The first view takes into consideration the stock of human capital, its level having an influence on the production output. The second view considers the accumulation of human capital as an important input factor: modifications in its level having effect on the output (Kiss, 2012: 65).

Human capital estimation methods can be divided in two major groups: monetary and non-monetary methods. The most commonly used monetary measures are the prospective method, retrospective method and the integrated approach. Furthermore, the non-monetary methods are basically measures of educational indicators.

MONETARY MEASURES OF HUMAN CAPITAL

Monetary methods of estimation allocate a monetary value to the stock of human capital, both at the individual and at the aggregate level. This gives the possibility to compare the stock of human capital with the one of physical capital (Le, Gibson and Oxley, 2003: 272).

The monetary measures can be grouped into three sub-groups: prospective measure, retrospective measure and the integrated approach. These estimation methods are described in more detail in the following sub-chapters.

PROSPECTIVE METHOD (INCOME-BASED APPROACH)

The name of the estimation method derives from the fact that it concentrates on the expected earnings from the human capital investment. Hence, this method is based on the estimation of future earnings. More precisely, this method estimates the present value of a person's future income stream, either net or gross of maintenance (Kiker, 1966: 481). Moreover, Dagum and Slottje (2000: 81) consider that the prospective approach "*provides… the human capital estimation at market price, since the labor market… [is] an interactive framework of human capital supply and demand"*.

The first estimation to calculate the value of human beings in monetary terms has been realized by Sir William Petty (1690). Petty calculates the value of human capital for England and Wales as the difference between national income and property income, capitalized at a 5% perpetual interest rate.

Kiker (1966: 482) argues that the first scientific approach has been developed by Farr (1853). Farr's method proposes to calculate the present value of the net future earnings by deducting the maintenance costs from the total earnings. The used capitalization rate is 5%, both for earnings and costs.

In the following years, several other researchers use the prospective method. For example, Wittstein (1867) applies Farr's method to estimate the human capital value of a person at several ages. Likewise, De Foville (1905) evaluates the value of human capital in France by capitalizing labor earnings minus the maintenance costs, whereas Barriol (1910) tries to assess the social value of an individual.

In 1930, Dublin and Lotka (1930), using Farr's method, conceive a formula for calculating the value of a person. Their study has been continued by several researchers, among whom it is worth mentioning Weisbrod (1961), Graham and Webb (1979), Mulligan and Sala-i-Martin (1997) or Le, Gibson and Oxley (2005).

According to Kiss (2012: 69), the stock of human capital of an economy can be approximated with the help of the prospective method by summing the total flux of every individual's capitalized earnings. This method takes into consideration all possible earnings a person can realize during his/her lifetime. The formula for estimating the gross level of human capital of an *a* years old person, with an *s* level of education is the following (assuming that the individual can realize earnings on the labor force market until the age of 75):

$$V_a^s = \sum_{x=a}^{75} \frac{y_x^s \cdot P_{a,x}^s \cdot E_x^s \cdot \left(1+g^s\right)^{x-a}}{\left(1+i\right)^{x-a}} \quad (1)$$

where i is the interest rate, E_x^s is the annual employment rate of an individual at age x and with an education level s, $P_{a,x}^s$ is the probability of an individual at age a and with an education level s surviving to age x, y_x^s represents the annual earnings of an individual with an

education level *s* from age *x* until age *x+1*, and g^s is the annual rate of increase in revenues.

However, this approach is not free from shortcomings. Kiss (2012: 69) warns about the estimation of future earnings and the selection of a proper discount rate. Moreover, Le, Gibson and Oxley (2003: 280) draw attention that the prospective method can lead to erroneous results since earning disparities can be caused not only by productivity differences but by other influences, as well, such as economic recessions or union agreements. In these latter cases, results will be biased.

The prospective model is based on the fact that earnings represent the human capital level of an individual. Still, there is a drawback in the fact that only the earnings of people who are working can be observed. It is merely an assumption that the earnings of persons who do no work during the observations could realize higher earnings. Thus, the observed earnings overestimate the real earnings (Kiss, 2012: 70).

At the same time, education level has an influence on the employment rate. Individuals with a higher level of education have better chances to find a job. Hence, the differences in unobserved earnings of these persons are less significant (Kiss, 2012: 70).

Additionally, the income based approach is quite sensitive to the discount rate and respectively to the retirement age. For this reason those who use this method have to be very careful in the way they use their results (Le, Gibson and Oxley, 2003: 280).

Among externalities of human capital investment there is health care, as well. If considering studies concluding that education level has a direct influence on health condition, than the likelihood to reach a certain age depends on the level of education (Kiss, 2012: 70).

Another delicate issue concerns the deduction of maintenance costs. According to the literature, there are two points of view. Some authors argue that since the estimations of physical capital are net figures, in order to be in accordance with these, human capital estimates have to be net figures, as well. However, Weisbrod (1961: 428-429) has faced major difficulties in his work trying to determine maintenance costs. Contrariwise, other authors consider consumption a scope of investment and production, rather than a means of these (Le, Gibson and Oxley, 2003: 281).

According to the human capital literature, in case of availability of necessary data, the prospective method provides the best results. However, Le, Gibson and Oxley (2003: 281) state that certain data on earnings are not as widely available as investment data. This is especially the case of developing countries.

With all the weaknesses of the prospective method, Graham and Webb (1979: 210) emphasize that „*it seems reasonable that a dynamic economy interested in assessing its future productive capacities would be more interested in the forward-looking present-value approach than in the historical-cost approach*".

RETROSPECTIVE METHOD (COST-BASED APPROACH)

The retrospective method is based on the „production" costs of human capital. Put in other words, this approach tries to determine the costs of producing human capital, adding up the education and schooling costs.

This approach has its origins in Engel's (1883) production costs method. Engel estimates human capital by calculating the rearing costs of a child until age 25. In his research, Engel assumes that the annual rearing costs are constant. Nonetheless, Engel suspects that the method cannot be applied for everybody: for example in case of prodigies like Newton or Goethe (Kiker, 1966: 483).

Dagum and Slottje (2000: 75) emphasize that Engel's method should not be considered an estimation of individual human capital, but merely as an approximation of historical costs that neglects the time value of money and the social costs invested in human beings. According to Le, Gibson and Oxley (2003: 74), Schultz (1961) and Machlup (1962) complete Engel's approach, creating what today is known as the retrospective method.

Unfortunately, this cost-based approach has several drawbacks. Firstly, when assessing the costs of physical capital, a relationship between investment and quality of production is not mandatory, since the value of the capital is given by the demand and not by the production costs. Le, Gibson, Oxley (2003: 274) argue that this problem is even more severe in the case of human capital. For example, the rearing costs of a less able and less healthy child are much higher compared with the rearing costs of a healthy and smart child. In this case, the retrospective method overestimates the human capital of the first child while underestimating the human capital of the second one.

The second shortcoming is that items that enter into the human capital production process, respectively their prices, are not well identified for this approach (Le, Gibson, Oxley (2003: 275). Kendrick (1976) argues that all rearing costs of a child until age 14 should be considered investments in human capital, since these costs compete with other types of investments. Instead, Bowman (in Le, Gibson, Oxley, 2003: 275) believes these costs should be treated as investments only in case the concerned persons are slaves.

A similar concern is the arbitrary categorization of the incurred costs as investments or as consumptions. Since all costs have both consumption (satisfying a need) and investment (enhancing productivity) effects, the prospective method is very sensitive concerning the researchers' assumptions. Precisely this impossibility of separation of the costs between consumption and investment makes it impossible to measure the changes occurred in the stock of human capital (Kiss, 2012: 71). At the same time, the change in the stock of human capital is difficult to measure for the reason that it is impossible to identify all human capital investments. Thus, their costs cannot be determined either.

A third limitation is the huge importance of the depreciation rates. Usually, simple tax accounting norms are used (Le, Gibson, Oxley, 2003: 275). Kendrick (1976) uses a double declining balance method in order to be in accordance with the physical capital depreciation method, while Eisner (1985) uses a simple straight-line practice.

A further disadvantage highlighted by Jorgenson and Fraumeni (1989) is that the retrospective method does not consider the value of non-market activities. The externalities of education are well-known, like the development of individual capacities, enjoyment or opportunity of self-fulfillment (Haveman and Wolfe, 1984: 389).

At the same time, Kiss (2012: 71) identifies a series of problems regarding the costs of the retrospective method. Hence, the approach assumes that each monetary unit invested in education will have the same effect, regardless of the level of education. In the same order of idea, not taking into account grade repetitions and dropouts represents another handicap. In case a student graduates in more years than the normal length of the graduation period, the costs of his/her education are higher (without increasing the student's knowledge). Hence, the retrospective method overestimates the student's human capital because of the higher incurred educational costs.

An equally important factor in determining educational costs is the assessment of the opportunity costs: those incomes that would have been earned if

the person would not have been enrolled in the educational system (Kiss, 2012: 72).

INTEGRATED APPROACH

Recognizing the limitations of the above presented methods, some authors have tried to estimate human capital by combining the prospective and the retrospective method. Doing so, authors hope to take advantage of the strengths, respectively to reduce the weaknesses of the two methods.

According to Tao and Stinson (1997: 3), a nation's aggregate human capital stock can be approximated in three ways. Firstly, the "potential" human capital is everybody's human capital, including those who are unable to work. Secondly, the "available" human capital is the human capital of those persons who are active in the labor market: working, searching or waiting for employment. Thirdly, the "effective" human capital belongs only to the individuals who directly participate in the production process.

Tao and Stinson's (1997:4) main idea is that investments in human capital determine the stock of human capital (retrospective method), which in turn determines individual earnings (prospective method).

Tao and Stinson (1997: 3) start from the following earning function, which establishes the relationship between human capital ($h^s_{i,j}$) and income ($E^s_{i,j}$):

$$E^s_{i,j} = w_t \cdot h^s_{i,j} \tag{2}$$

where s, *i* and *j* represent the sex, age and educational level, and w_t is the salary of a person in year *t*.

The model reflects the assumption of the human capital theory that individual earnings are influenced by the magnitude of the human capital (Kiss, 2012: 74). A linear relationship between earnings and human capital is assumed, where the proportionality coefficient is the rental rate of the human capital.

Since the variables from the right side cannot be directly observed, Tao and Stinson choose to standardize the human capital stock of the graduates of secondary education who decide to get a job immediately after graduation. This choice is made because of two reasons. Firstly, modifications in the human capital stock of these graduates do not have to be taken into consideration due to the (lack of) experience and training at the workplace conditions. Secondly, the abilities of the graduates are known from the SAT scores.

Tao and Stinson estimate the human capital stock of the graduates from the secondary education starting with the retrospective method (cost-based approach). They assume that the stock of human capital corresponds to the total costs invested in education. However, since the income of the fresh graduates is not known, Tao and Stinson assume that these individuals are paid according to their abilities (which can be traced back to the SAT scores).

Thereby, knowing the levels of human capital and the earnings, the rental rate of the human capital (*w*) can be calculated for the fresh graduates. Knowing the earnings of the other cohorts and assuming the rental rate is constant for all the cohorts, Tao and Stinson are able to calculate the human capital stock for the rest of the cohorts, as well.

In their estimation, Tao and Stinson take into consideration only the education costs. They appreciate that health costs are already reflected in a better health status, which implies a higher income. Therefore, if health costs would be added to the graduates' human capital, this would represent a double counting of the health costs (Tao and Stinson, 1997: 22).

However, the method has some shortcomings. Tao and Stinson do not take

into consideration (within the human capital investment) the rearing costs of the secondary education graduates, considering them consumption costs. As mentioned in the previous sub-chapters, categorizing rearing costs as investments or as consumptions is highly controversial.

Another delicate issue is related to the prospective method (income-based approach). The integrated model assumes that fresh graduates of secondary school are being paid according to their abilities, measured by the SAT scores. However, SAT scores might not be the best way to measure abilities, since these tests are completed voluntarily, especially by students who want to attend a higher education institution. Hence, the students who complete the SAT tests are the more competent ones, who wish to continue their studies.

Additionally, this method does not allow comparative analysis as admission exams to higher education institutions differ across countries.

Another integrated method is Dagum and Slottje's (2000) approach, which estimates the national and personal human capital in monetary terms. At the same time, Judson's (2002) approach is a specific integrated approach: he estimates human capital based on combining the retrospective method (educational expenses made by the state) with a non-monetary method (average educational performances).

NON-MONETARY MEASURES OF HUMAN CAPITAL (EDUCATION-BASED APPROACH)

Non-monetary methods consider the estimation of human capital from the perspective of the investments in education, without allocating any monetary values to the human capital. The most used indicators of this education-based approach are literacy rates, enrolment rates, repetition and dropout rates, average years of schooling and test scores.

According to Le, Gibson and Oxley (2005: 18) the basis of this method is that the used indicators are strictly linked to the investment in education, which is the main component in the formation of human capital. Moreover, the used educational indicators are not direct measures of human capital but only proxy variables of it.

Obviously, human capital has several components, but education is the most important one of them. Haveman and Wolfe (1984: 389) argue that, besides economic opportunities, education can have additional non-market benefits, as well. Moreover, Le, Gibson and Oxley (2005: 18) stress the major role education plays at macro level, especially in the economic, institutional and social development process.

ADULT LITERACY RATES

Le, Gibson and Oxley (2005: 18) state that this indicator has been used in the first empirical investigations regarding the effect of human capital on economic growth. Moreover, Wößmann (2003a: 243) emphasizes that literacy rates are chosen in most studies because of data availability and of the comprehensive geographical coverage rather than simple theoretical suitability. Hence, when used in cross-country growth regressions, literacy rates tend to have limited explanatory capabilities.

A less significant deficiency is that literacy has different definitions across countries, which creates biases when comparing them. However, a more delicate problem lies in the fact that although literacy rate captures a main element of human capital, it omits most of the other components of human capital, which spread beyond certain fundamental levels (Le, Gibson and Oxley, 2005: 18).

According to Kiss (2012: 78), literacy rates can be relevant in case of particular international comparative analyses where the main objective is the investigation and comparison of general and/or elementary knowledge. The same Kiss (2012: 78) concludes that literacy rates are appropriate especially in comparisons of less developed countries. Likewise, Judson (2002: 227) appreciates that literacy rates can be good proxy measures for human capital accumulation in case of countries with less educated population, but not in the case of countries with universal primary education which register an expansion at the levels of high school and college education.

SCHOOL ENROLLMENT RATES

An additional human capital proxy used in the literature is the school enrollment ratio. This indicator measures the number of students enrolled at a given level relative to the total population of the corresponding age group. Net or gross enrollment rates depend upon the numerator of the ratio. Hence, gross ratios count the total number of students whereas net ratios consider only students between a certain age groups.

Wößmann (2003a: 244) argues that enrollment rates are flow variables and the currently enrolled students are not yet part of the production force. Consequently, the education students are receiving in the present-day cannot be used in the current production process. According to Le, Gibson and Oxley (2005: 19), enrollment rates measure the current investment in human capital, which will be manifested in the future stock of human capital.

Therefore, school enrollment rates might not be the best proxies to measure the current stock of human capital. In the first place, being a flow variable, enrollment rates capture merely parts of the constant human capital accumulation. Second, Pscacharopoulos and Arriagada (1986: 561-562) observe, as well, the aforementioned time delay between the investments in education and the accumulations in the human capital stock, stressing that enrollment rates measure the schooling level of the forthcoming labor force. Third, the education of the present-day students cannot be completely added to the future stock of human capital since graduates can decide not to take part in the labor force after finishing school. Fourth, the modification in the human capital stock is the difference between the human capital of the people who enter and those who leave the labor force. Unfortunately, the enrollment rates do not take into consideration the human capital of the latter. Consequently, the school enrollment rates are limited proxies of the flow of human capital investment.

Furthermore, there is a reliability problem concerning data on school enrollment rates from developing countries (Le, Gibson and Oxley, 2005: 19). Regarding data drawbacks, Barro and Lee (1993: 5) declare that UNESCO enrollment data might be flawed, as well, because the national reporters of the data tend to exaggerate figures for the interests of their own institutions. At the same time, Wolff (2000: 436) suggests the existence of a reverse causality between enrollment rates and productivity growth: high enrollment rates being a consequence of high productivity growth and not the other way around.

Le, Gibson and Oxley (2005: 19) conclude that enrollment rates can be acceptable proxies of human capital for certain countries but not for all of them. Similarly, Judson (2002: 229) declares that secondary enrollment rates are good human capital proxies only in the case of countries with major expansion in secondary education.

AVERAGE YEARS OF EDUCATION

The insufficiencies of the above presented human capital proxies have urged scientists to search for a better indicator: the average years of schooling. This educational performance is a stock indicator, which considers the total formal education of the current labor force (Kiss, 2012: 78). Moreover, Le, Gibson and Oxley (2005: 19) add to this definition the assumption that the human capital of the workers is proportional to the years of attained education.

This estimation method has several advantages if compared to the before mentioned two estimation methods. First and foremost, it is a compelling stock measure. Second, by reflecting the total quantity of formal education, years of schooling indicate the human capital available in the economic production process. Third, Wachtel (1997: 194) affirms that under a certain set of assumptions and by using the retrospective method, the number of schooling years is an accurate measure of educational human capital.

According to Wößmann (2003a: 245), the average years of education are the prevalent and mostly used measurement method of the human capital in the literature.

Given that aggregate primary data on years of schooling are usually unavailable, researchers have to construct their data set by using different techniques. Usually, these construction techniques are based on UNESCO data on enrollment and attainment levels. Moreover, Wößmann (2003a: 20) classifies the construction techniques into three separate groups: the census (or survey) based method, the projection method and the perpetual inventory method.

The survey/census based method.

This method uses direct measures of educational attainment levels from censuses and/or surveys. Pscacharopoulos and Arriagada (1986) are the first who estimate average years of education (S^{ATT}) for the labor force from 99 countries, using the following formula:

$$S^{ATT} = \sum L_i \cdot D_i \quad (3)$$

where L_i is the proportion of the labor force with an i level of education, D_i is the time duration in years of the i^{th} level of education, and i includes illiteracy, incomplete primary, completed primary, incomplete secondary, completed secondary and university education.

Data regarding L_i has been directly available for 66 countries (from national censuses and surveys). For the rest of 33 countries, data had to be constructed based on information on the educational composition of the population.

However, the obtained data set has some drawbacks, as well. Le, Gibson and Oxley (2005: 20) draw attention that for fractions of the labor force who did not finish a certain level of education, the authors attribute half of the normal period of the corresponding level of education. Given that dropout rates are very different across countries this random assumption can lead to measurement errors.

According to Wößmann (2003a: 246-247), the main limitation of the data set is the fact that the observation years vary significantly from country to country: extending from 1960 to 1983. Additionally, another disadvantage is that more than one observation has been available in only 34 countries.

At the same time, as Barro and Lee (1993: 7) observe, the definitions of the labor force differ greatly across countries. Hence, a cross-country analysis is difficult to obtain.

Projection method

Kyriacou (1991) tries to overcome the impediment of the Psacharopoulos and Arriagada (1986) data set by using a projection method (or *regression method*). Kyriacou starts from the assumption that there is a strong relationship between average years of education and gross enrollment rates. He obtains the necessary data from already existing studies: the enrollment rates from UNESCO Statistical Yearbooks whereas the average years of education from Psacharopoulos and Arriagada (1986).

Considering the strong relationship between enrollment rates and average years of education (R^2=0.82), Kyriacou (1991: 5) uses the enrollment rates to forecast the average years of education of the labor force:

$$S_{1975} = {}_1 + {}_2 Prim_{1960} + {}_3 Sec_{1970} + {}_4 High_{1970} \quad (4)$$

where S_{1975} represent the average years of education of the labor force for the year 1975, respectively *Prim*, *Sec* and *High* are the enrollment rates for primary, secondary and higher education. Using this method, Kyriacou (1991: 5) makes five observations – for the years 1965, 1970, 1975, 1980 and 1985 – for the majority of the 113 countries covered.

However, Le, Gibson and Oxley (2005: 21) highlight that the opulence of Kyriacou's data set is due to a major measurement error. At the same time, Wösmann (2003: 246) notices Kyriacou's (erroneous) presumption that the relationship between the average years of education and the lagged enrollment rates is stable over time and across countries. Moreover, Barro and Lee (1993: 9) dismantle this assumption based on previous discussions of the UNESCO (1978).

Likewise, assumptions have been made about the length of each educational level, dropout rates and repetition rates. These improper assumptions explain why the data is well correlated for the mid '70s and why it differs so much for other periods of time (Le, Gibson and Oxley, 2005: 21).

Hence, the validation of Kyriacou's method requires the assumption of a strong relationship over time and across countries between the average years of schooling and the lagged enrollment rates.

Permanent inventory method.

A third method to determine the average years of education is the permanent inventory method (PIM). Wößmann (2003a: 245) specifies that this method can be used only in case of the existence of a sufficiently long data series on school enrollment rates. The first researchers who have used the PIM are Lau, Jamison and Louat (1991) and, respectively, Nehru, Swanson and Dubey (1995).

The study of Lau et al (1991) is realized for the period 1965-1985, on a sample of 58 developing countries from five regions of the world, for primary and secondary education. Higher education is omitted due to missing data for the majority of countries.

According to Lau et al. (1991), the human capital stock is given by the total years of schooling of the working age persons (aged between 15 and 64). Lau et al. (1991) calculate the educational stock *S* for year *T* by adding the school enrollments *E* at all grade levels *g* for all age cohorts:

$$S_T = \sum_{t-a_{\max}+6}^{T-a_{\min}+6} \sum_{g=1}^{g_{\max}} E_{g,t} P_{g,t} \quad (5)$$

where $P_{g,t}$ is the probability that a student enrolled in grade g at moment t to survive until year T, and a_{min}=15 respectively a_{max}=64 are the working ages.

Several authors underline the data demanding character of this method. The estimation of the total years of education of the working age people for the period 1965-1985 necessitates data series on enrollments and mortality probabilities starting from 1907. Due to lack of data on pre-1950 and post-1980 enrollments, these data had to be "fabricated" through different statistical approaches. Because of this reason and due to the lack of benchmarking census data, the estimations of Lau et al. (1991) are weakly correlated with those of Psacharopoulos and Arriagada (1986).

Nehru et al. (1995) improve the method of Lau et al. (1991) by introducing dropout and repetition rates into the formula:

$$S_T = \sum_{t-a_{\max}+D_o}^{T-a_{\min}+D_0} \sum_{g=1}^{g_{\max}} E_{g,t+g-1}\left(1-r_g-d\right)P_{g,t+g-1} \quad (6)$$

where D_0 is the age at which children start going to school (usually six), r_g is the repetition rate in grade g (assumed to be constant over time), d is the dropout rate (assumed to be constant over time and grades). For the majority of countries Nehru et al. collect enrollment data starting from 1930 and in some cases even from 1902. The average years of education (S^{PIM}) is obtained by normalizing the total number of school years (S_T) with the number of the working age population (L_T):

$$S^{PIM} = \frac{S_T}{L_T} \quad (7)$$

However, Wößmann (2003a: 266) states that the PIM formula used by Nehru et al. is erroneous. Moreover, the fact that the authors ignore census data on school attainment reduces the importance of the obtained results. Nehru et al. argue that the census based estimations are not automatically superior to the PIM estimates. This is the main reason why De la Fuente and Doménech (2006: 4) criticize Nehru et al.'s study, stating that it is difficult to justify why Nehru et al. did not consider the only direct information available on the variables of interest.

QUALITY OF SCHOOLING

Wößmann (2003a: 253) underlines the fact that not only the quantity of education (average years of education) differs across countries but the quality of each year of education, as well (cognitive skill acquired during schooling).

Hanushek and Kimko (2000: 1184) suggest that the qualitative aspects have been overlooked in the economic growth models because of the higher importance given to the quantitative variations of human capital. Nonetheless, they stress that explaining differences in the labor force quality improves the chances to explain economic growth rates. This idea is supported by Wößmann (2003a: 253), as well, who recommends the introduction of qualitative differentiations in human capital estimations, additionally to the quantitative differentiations. The same Wößmann (2003a: 253) suggests three ways on how to adjust the human capital function to qualitative differences.

Educational Inputs

A first effort would be to use proxy variables for estimating the quality of educational inputs. These input approximations are then introduced in growth regression analyses, as individual explanatory variables; with the assumption that it will attest an additional effect of human capital.

The student-teacher ratio – one the first such input variables – is used by Barro (1991) as a proxy for determining the quality of education. Other such proxy variables used by Barro and Lee (1996),

Barro and Sala-i-Martin (1995) and Lee and Barro (2001) are the followings: the ratio of educational public spendings to GDP, the educational expenditures per student, the estimated teacher salaries or the length of a school year.

Nevertheless, Hanushek (1996: 17-18) shows that these evaluations of educational inputs are not strongly correlated to the cognitive skills acquired through education, which means that the educational inputs are poor proxies of the schooling quality.

Simultaneously, the same Wößmann (2003b: 156) becomes a critic of this effort by stating that the estimates do not take into consideration the efficiency of different educational systems where they are used. Put in other words, institutional arrangements of educational systems could have a higher role in understanding student performances.

Country-Specific Rates of Return (to education)

The second suggestion for estimating qualitative differences is the country-specific rates of return. However, this specification is based on three main assumptions: international labor markets are perfectly competitive, global labor is perfectly mobile and employers are perfectly informed about their workers' human capital (Wößmann, 2003a: 254). If all the above mentioned assumptions are taken into consideration, differences in country-specific rates of return can capture the differences in the educational quality of the work force. Hence, these rates can demonstrate the educational quality differences across countries.

Moreover, a measurement of the quality-adjusted stock of human capital could be particularized as (Wößmann, 2003a: 254):

$$h_i^r = e^{\sum_a r_{ai} s_{ai}} \quad (8)$$

where h_i^r is the human capital per worker in country *i*, r_{ai} is the rate of return to education at level *a* in country *i*, and s_{ai} represents the average years of schooling at level *a* in country *i*.

Unluckily, the data regarding country-specific rates of return has severe measurement errors. Additionally, the three underlying assumptions are beyond any doubt wrong. Therefore, this suggestion does not capture well the qualitative differences in education, either.

Direct tests of cognitive skills

A third method for highlighting differences in the quality of schooling is constructed on direct measurements of individual cognitive skills, acquired from direct tests. Le, Gibson and Oxley (2005: 26) suggest that test scores are quite attractive human capital indicators since they measure educational outcomes, cognitive skills and at the same time they assure international comparison, as well.

According to Hanushek and Kim (1995: 13), the most important cognitive tests have been realized through six international evaluations, performed in the field of mathematics and science. Four such testings have been administered by the International Association for the Evaluation of Educational Achievement (IEA) and two by the International Assessment of Educational Progress (IAEP). Moreover, different tests include separate tests for students from different age groups respectively for different sub-domains of subjects (Wößmann, 2003a: 255).

The multitude of quality measurements, out of which many are poorly correlated with each other or with quantitative measurements of education, creates rather a confusion than to solve the

riddle of human capital measurement. It is at least odd that the results of the education based measurements of human capital are often in contradiction with each others (Le, Gibson and Oxley, 2005: 26). For this reason, Hanushek and Kimko (2000: 1187) develop a unique measurement of labor force quality, by combining all the available information on the obtained results from international mathematics and science tests.

This method has the advantage to combine diverse indicators of education in one index. At the same time, Hanushek and Kimko's method can mislead, as well, because test scores can reflect (besides quality of education) other variables like innate abilities, too. Furthermore, due to lack of available data, Hanushek and Kimko (2000: 1185) are obliged to attribute missing values with the help of a regression method; by this, confronting themselves with the problem of low data quality (Le, Gibson and Oxley, 2005: 27).

Wößmann (2003) improves the method by incorporating its qualitative estimates into estimates of the human capital stock. Hence, Wößmann (2003: 255) normalizes Hanushek and Kimko's educational quality indicators for each country relative to the measurement for the USA. World average rates of return to education are integrated in the final specification of the human capital stock, obtaining the following quality adjusted estimation of human capital Wößmann (2003: 255):

$$h_i^Q = e^{\sum_a r_a Q_i s_{ai}} \quad (9)$$

where r_a represents the world average rate of return at education level a, Q_i is the Hanushek and Kimko's (2000) educational quality index for country i relative to the value for the USA, and s_{ai} represents the average years of education for level a in country i.

The used data are taken from several authors: the average years of education are from Barro and Lee (2001), the world average rates of return from Psacharopoulos (1994), and the aggregate estimates of educational quality from Hanushek and Kimko (2000).

Wößmann (2003: 255-256) argues that his method has the advantage of allowing an endless growth to human capital and without an upper bound, exactly like the case of physical capital. Moreover, Le, Gibson and Oxley (2005: 27) recognize the fact that Wößmann's method is a comprehensive one because it manages to explain various quantitative as well as qualitative properties of education. However, one drawback of this method is its data demanding character. Additionally, if the data taken from Barro and Lee (2001), Psacharopoulos (1994), Hanushek and Kimko (2000) are biased than Wößmann's data will be biased, as well.

CONCLUSIONS

As concluding remarks, all of the above presented monetary and non-monetary measures of human capital have certain strengths and weaknesses. This paper has tried to present both the positive aspects and the shortcomings of each method. The choice of a certain method should be based on these strengths and weakness; respectively on the availability of data and especially on the researcher’s proposed objectives.

Despite the contrasts, the cost-, income- and education-based approaches have a certain connection between each other. The retrospective approach is formed by the inputs in the human capital production process (like rearing and educational costs). On the other hand, the prospective approach is based on the earnings of people, which are the outcomes of the human capital production process. Likewise, the education-based indicators can be considered outcomes of

the human capital production process, as well.

Moreover, beside the above presented approaches there are several other human capital estimation methods. A very specific method considers the characteristics of the quality of education. This method can be separated into three groups: methods based on educational inputs, methods based on country specific rates of return or direct test results. However, the measurement of educational quality is a very sensitive issue, most researchers having contradictory opinions about the qualitative approaches.

It is important to remark the transformation that went on in the rationale behind human capital assessment. The initial evaluations of human capital have been trying to highlight national strengths by estimating in monetary terms the losses from wars or the wealth of a country. However, in the last decades the emphasis has been transferred to the existing relationship between human capital and economic growth. It is believed human capital plays a major role in the growth process, as well as yielding positive externalities.

Unfortunately, the effect of human capital on economic growth lacks empirical consensus since none of the theoretical foundations are free of drawbacks. All of the approaches confront themselves with one of these two errors: either the evaluation method does not reveal significant elements of human capital or the used data set is of poor quality. Thus, the appropriate estimation method of human capital remains a challenge.

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