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A Brief Introduction to Human Capital Measures

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ABSTRACT

A Brief Introduction to Human Capital Measures[1]

There are six major measures of human capital, each of which covers at least 130 countries, all of which are described in this paper. These measures are of two distinct types: monetary and index-based. The two monetary versions are those by the World Bank (Lange et al., 2018) and by the United Nations Environmental Program and the Urban Institute of Kyushu University (Managi and Kumar et al., 2018). The four indicator versions are by the Institute of Health Metrics and Evaluation of the University of Washington (Lim et al., 2018), the United Nations Development Programme (UNDP, 2019), the World Bank (International Bank for Reconstruction and Development and the World Bank, 2018), and the World Economic Forum (World Economic Forum, 2017). In addition to describing each of these six measures, this paper compares them using ranking (Spearman) and level (Pearson) correlations. This paper was written as an introduction to a forthcoming book (Fraumeni, Barbara M., ed., Measuring Human Capital, Academic Press, Cambridge, MA) on human capital in order to help statisticians, researchers, analysts, policy-makers and government officials make an informed choice about which to use as this decision can matter.

JEL Classification: J24, O57

Keywords: human capital, international comparisons, methodology, monetary and index-based measures

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1 The forthcoming book includes chapters on the UNECE and Urban Institute of Kyushu University, UNDP, and both World Bank measures. IHME had to withdraw from this project when its priorities had to be re-organized due to the COVID-19 virus. The editor was unsuccessful in contacting WEF to see if they would be willing to contribute. The forthcoming book also includes two other chapters, one on human capital in China and another on human capital in the United States.

Human capital can be regarded as 'the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being' (OECD, 2001). The notion of human capital being equally essential as conventional tangible capital can at least be traced back to Adam Smith's work in the 18th century (Smith, 1776), but it was not widely recognized until around the 1960s, when economists began to use it to investigate income and growth differentials (e.g. Mincer, 1958, 1962; Schultz, 1961, 1962; Becker, 1962, 1964).

In the 1980s and 1990s, human capital regained its importance both within the neoclassical growth accounting framework (e.g. Jorgenson and Fraumeni, 1989, 1992a, 1992b) and through the endogenous growth models (e.g. Romer, 1986; Lucas, 1988; Mankiw *et al*. 1992). It was also employed regularly in the development accounting works (e.g. Klenow and Rodriguez-Clare, 1997; Hall and Jones, 1999).

Measures of human capital can serve many purposes as human capital is a key indicator of the current and future potential of a country and its individuals. In most countries, human capital is the largest form of wealth. In others where natural resources are the largest form of wealth, human capital is often a growing source of wealth (Lange *et al*., 2018; Managi and Kumar, 2018). Countries with a relatively young population can have significant advantages over countries with older populations over the longer term. Within the context of sustainable development human capital measures can be used to gauge how well a country is managing its total national wealth, with the purpose of assessing its long-term sustainability (e.g. UNECE, 2009). There are both monetary and non-monetary, including subjective, ramifications of the level of human capital (Dolan *et al*., 2008). Most recently, human capital is frequently applied to inform 'beyond GDP' discussions, since its distribution across households and individuals and the non-economic benefits due to its investment are among the crucial determinants of people's 'quality of life' and well-being (e.g. Stiglitz *et al*., 2010; OECD, 2011, 2013, 2015, 2017).

The forthcoming book (Fraumeni, ed.) is about measuring human capital.[2] Currently existing human capital measures can be divided into two broad categories: the indicators-based and the monetary measures.[3] Except for the Introduction chapter, all the other six chapters collected in the forthcoming book reflect this division, with two chapters applying the indicators-based approach, while the other four using monetary measures. The monetary measures emphasize demographics such as age and education with underlying gender break-outs, as well as income, while the indicator-based measures have a wide-array of types of components in addition such as health, standard of living, deployment, and know-how.

Another distinct feature of the forthcoming book is its global perspective, with four chapters focusing directly on large projects for international human capital comparisons that have been undertaken by

[2] This paper is a modified version of the introduction to the forthcoming book. It omits a discussion of the two country study chapters, one, which is about human capital in China and the other, which is about human capital in the United States.

[3] For an overview of the different measures of human capital within and across the two broad categories, please refer to e.g. Liu and Fraumeni (2016).

several international organizations and/or universities.[4] Each covers at least 130 countries. While the other two chapters are single-country studies, the two countries respectively addressed are the United States of America and the People's Republic of China, nowadays two of the three largest economies in the world.

With various human capital measures being discussed, the forthcoming book does not take the stand that there exists one specific measure that should be used under any circumstances, rather, it is intended to serve as one of the valuable resources for statisticians, researchers, analysts, policy-makers, and government officials in searching for comparable information, so as to make their own decisions on what human capital measures are best suitable for their purpose.

In the following, a brief description of different methodologies applied in the projects for human capital comparisons is provided. However, readers are strongly encouraged to read every and each individual chapter in the forthcoming book in order to have a more comprehensive and deeper understanding of why and how the different detailed methodologies were implemented in practice. A simple comparison of the results is then discussed, with the purpose of giving a flavor of taste of the rich information that can be drawn from these studies.

I.1 Monetary-based measures projects

The first two chapters are excellent examples of comparing human capital across countries by applying the monetary measures. In both examples, human capital is measured together with non-human capital (such as conventional fixed capital and natural capital) within a consistent framework of comprehensive wealth accounting, with the goal being to help governments plan for a more sustainable economic future.

Chapter 1 is about the World Bank's latest wealth accounts that cover the period 1995–2014 for 141 countries (Lange *et al*., 2018). Plenty of data from the accounts, including country human capital measures in constant 2014 US$, were presented in the 2018 report: *The Changing Wealth of Nations 2018: Building a Sustainable Future* (CWON hereafter).

In the World Bank's previous works, human capital was not measured explicitly but included in a residual resulting from deducting produced capital, natural capital, and net foreign assets from total national wealth that was calculated as the present value of future consumption (World Bank, 2006, 2011). Although a large part of this residual could be attributed to human capital (e.g. Ferreira and Hamilton, 2010; Hamilton and Liu, 2014), the non-explicit measure of human capital makes it difficult for policy-making.

Human capital in the new CWON wealth accounts was measured by applying the well-known Jorgenson-Fraumeni lifetime income approach (Jorgenson and Fraumeni, 1989, 1992a, 1992b), based on a unique database developed by the World Bank, the International Income Distribution Database, which contains more than 1,500 household surveys. When a household survey is not available for any country for a given year, previous or later surveys that are controlled by country-wide totals for the non-survey years are then used as the basis for these years.

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[4] Originally the Institute for Health Metrics and Evaluation (IHME) of the University of Washington was going to contribute to this book, however, IHME withdrew from this project when its priorities had to be re-organized due to the COVID-19 virus. See Lim *et al*. (2018) for a description of the IHME human capital measures.

First, for each country and year covered by the CWON project, wage profiles by age, education, and gender were derived by applying the estimated parameters from Mincer equations (Montenegro and Patrinos, 2016). Then, the estimated wage profiles were benchmarked to the total employment and the compensation of employees that are drawn from UN, ILO databases, the Penn World Table (Feenstra *et al*., 2015), and other sources.

For an individual in the working age population (aged 15-65), the lifetime income is calculated as:

$$\text{(I.1)} \quad h_{a,e} = p_{a,e}^{m} w_{a,e}^{m} + \left(1 - r_{a,e}^{e+1}\right) * \varphi * v_{a+1} * h_{a+1,e} + r_{a,e}^{e+1} * \varphi * v_{a+1} * h_{a+1,e+1} \,,$$

where

$h_{a,e}$	=	lifetime income for an individual with age of '*a*' and education of '*e*';
$p_{a,e}^{m}$	=	probability to be employed;
$w_{a,e}^{m}$	=	received compensation of employees when employed;
$r_{a,e}^{e+1}$	=	school enrolment rate for taking one more year's education from education of '*e*' to one-year higher level of '*e*+1' (assuming equal to 0 for those aged 25-65);
φ	=	adjustment factor;[5]
v_{a+1}	=	survival rate (probability of surviving one more year).

Equation (I.1) indicates that the lifetime income of an individual is estimated as the sum of two parts: the first part is the current labor income, adjusted by the probability of being employed ($p_{a,e}^{m} w_{a,e}^{m}$); the second part is the expected lifetime income in the next year, which can be elaborated on as the following: in the next year the individual will be confronted to two courses of action: the first is to continue to work (holding the same education level as before) and earn income of $\varphi * v_{a+1} * h_{a+1,e}$, with the probability of $\left(1 - r_{a,e}^{e+1}\right)$; the second is to take one more year education and (after finishing) to receive income as $\varphi * v_{a+1} * h_{a+1,e+1}$, with the probability of $r_{a,e}^{e+1}$.

Chapter 2 is about the biennial *Inclusive Wealth Report* (IWR hereafter), the latest of which was published in 2018, with annual data (in 2005 PPP US$) covering the period 1990-2014 for 140 countries (Managi and Kumar, 2018). The IWR project has built up its comprehensive wealth accounting by following a framework developed by Arrow *et al*. (2012, 2013) and Klenow and Rodríguez-Clare (1997).[6]

Within this framework, for each country and year, human capital per capita due to education is measured as:

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[5] The adjustment factor (φ) is defined in terms of the real rate of labor income growth (g) and a discount rate (σ), i.e. $\varphi = (1+ g)/(1+ \sigma)$.

[6] The 2018 IWR project calculated two different versions of wealth: conventional and frontier, the latter including health capital as a component of human capital wealth. In the forthcoming book and in this paper, conventional wealth is described and used in comparisons as it is most similar in coverage to the World Bank CWON monetary measure (Lange *et al.* 2018).

(I.2) $h_E = \left(e^{\rho E} * P_{5+E} * \int_0^T w(\tau)e^{-\delta\tau}d\tau\right)/P,$

where

h_E	=	human capital per capita with the average years of total schooling '*E*';
ρ	=	rate of return on education (assumed to be 8.5%);
P_{5+E}	=	population who has had education equal to or greater than '*E*';
w	=	average compensation to employees;
T	=	expected working years;
δ	=	discount rate (assumed to be 8.5%);
P	=	total population.

Equation (I.2) shows that human capital per capita is calculated as the total human capital divided by total population, while the former is measured as a multiplication of one unit of human capital ($e^{\rho E}$), the corresponding population (P_{5+E}), and the shadow price of one unit of human capital ($\int_0^T w(\tau)e^{-\delta\tau}d\tau$). *E* is the average years of school completed by the population. The shadow price is calculated by the present value of lifetime income, which is proxied by that of the average compensation to employees (*w*) over the expected working years (*T*).

Note that both the CWON and IWR projects make the estimates of human capital per capita, indicated by Equations (I.1) and (I.2) respectively. However, the CWON project makes use of household surveys data which offer detailed information at disaggregated level, while the IWR project does not depend on such detailed survey data, and therefore, is less data demanding. The IWR project computes human capital for the whole population, while CWON estimates human capital for those who earn labor income. The IWR project uses a snapshot of the average level of education for the country as a whole, while CWON allows for additional education of individuals over their lifetime because of the more extensive data base it has.

Monetary measures are being considered as a basis for incorporating human capital into expanded accounts of the System of National Accounts (SNA) (Smedes forthcoming).[7]

I.2 Indicators-based measures projects

Chapters 3 and 4 are two outstanding examples of comparing country human capital by using the indicators-based measures, i.e. by constructing various composite indexes for human capital.

Chapter 3 is about the World Bank's Human Capital Index (WB HCI hereafter) (see IBRD and World Bank, 2018). Chapter 4 presents the United Nation's Human Development Index (UN HDI hereafter) published in the Human Development Report that has been issued by the United Nations Development Programme (UNDP) since 1990 (see e.g. UNDP, 2019).

Table I.1 lists a number of selected characteristics among three human capital indexes compiled internationally, including that constructed by the Institute for Health Metrics and Evaluation (IHME

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[7] Two possible approaches to integrating human capital into the SNA have been developed (Liu 2015; chapter 6 of UNECE 2016).

HCI hereafter) at University of Washington in the US (see Lim *et al*., 2018). As shown, the WB HCI and the IHME HCI are built upon two basic dimensions: education and health, because the two indexes focus on how human capital can be expected to enhance productivity through these two most important investment channels.

Table I.1 Comparison of selected characteristics among different human capital indexes

	WB HCI	IHME HCI	UN HDI
Latest publication date	2018	2018	2019
Coverage (year)	2018	1990-2016	1990-2018
Coverage (country/economy)	157	195	189
Coverage (gender)	Both	Both	Both
Definition of index	The amount of human capital a child born in 2018 can expect to acquire by age 18	Expected years lived from age 20 to 64 years, adjusted for educational attainment, learning, and functional health status	A summary measure of achievements in three key dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living
Value range of index	[0-1]	[0-45]	[0-1]
Components of Index			
1. *Education*			
Quantity of Education	Expected years by age 18 of those who start preschool earliest at age 4; range = [0-14]	Average years of completed schooling, by 5-year age groups, from 5 to 24; range = [0-18]	Expected years with range = [0-18] Mean years with range = [0-15]
Quality of Education	Harmonized average test score (out of a benchmark score of 625)	Harmonized average test score, relative to highest national average score, by 5-year age groups, from 5 to 19, scaled [0-1]	
2. *Health*			
Health indicators (Adults)	Share of 15-year-olds who survive until age 60	Expected years lived from age 20 to 64; Prevalence of health conditions linked to productivity/learning: anemia, cognitive impairment, hearing loss, vision loss, infectious diseases, by 5-year age groups, from age 20 to 64, scaled [0-1]	Life expectancy; range = [20-85]
Health indicators (Children)	Stunting and mortality rates among children under age 5	Stunting and wasting rates among children under age 5	
3. *Standard of living*			Ln (Gross National Income per capita in 2011 PPP $); range = [ln(100)-ln(75,000)]
Data sources	Various UN databases; UNICEF-WHO-World Bank Joint database; Data provided by World Bank staff; Student achievement tests from 162 economies in Patrinos and Angrist (2018)	Global Burden of Diseases, Injuries, and Risk Factors Study 2016; 2522 censuses and household surveys from 194 countries; 1894 student achievement tests from 132 countries and 163 subnational locations	ICF Macro Demographic and Health Surveys; Various databases from UN, World Bank, IMF and OECD; Barro and Lee (2018)

Source: IBRD and World Bank (2018); Lim *et al*. (2018); UNDP (2019)

In addition to education and health, the UNDP HDI has one more dimension in its index construction: standard of living, which is represented by the indicator of gross national income per capita in a country. The reason is that the UN HDI aims to illustrate the current state of development of a country/economy.

Both the WB HCI and IHME HCI have indicators for addressing the quality of education, while these are missing in the UN HDI. In terms of heath indicators, the IHME HCI has much richer information that are drawn from a unique and profoundly comprehensive database: The Global Burden of Diseases, Injuries, and Risk Factors Study 2016 (Murray *et al*., 2017).

Besides the differences and similarities as listed in Table I.1, how the human capital index is practically constructed also differs across projects. The composite index of the WB HCI is compiled as follows:

(I.3) $$WB\ HCI = \frac{P}{P^*} * e^{\emptyset(S_{NG}-S^*)} * e^{\gamma(Z_{NG}-Z^*)},$$

where

P	=	probability that a child born today survives;
P^*	=	benchmark of complete survival, equal to 1;
$\emptyset$	=	increase in productivity per additional year of school, equal to 8%;
S_{NG}	=	expected future education;
S^*	=	benchmark of complete quality-adjusted schooling, equal to 14 years;
γ	=	estimated return to productivity per unit increase in each health indicator (0.65 for adult survival rate and 0.35 for not-stunted rate);
Z_{NG}	=	expected future health;
Z^*	=	benchmark of complete health, equal to 1.

In Equation (I.3), the WB HCI index measures the human capital of the next generation, which is the amount of human capital that a child born today can expect to achieve in view of the risks of poor health and poor education currently prevailing in the country where that child lives. Therefore, the WB HCI is designed to highlight how investments that improve health and education outcomes today will affect the productivity of future generations of workers. In addition, it is a measure of productivity relative to the benchmark of full health and complete education, an ideal scenario.

The composite index of the IHME HCI is compiled as follows:

(I.4) $$IHME\ HCI = \left(\frac{\sum_{x=20}^{64} nL_{xt}FH_{xt}}{l_0}\right) * \left(\frac{\sum_{x=5}^{24} Edu_{xt}Learn_{xt}}{18}\right),$$

where

nL_{xt}	=	expected years lived in age group *x* for year *t*;
FH_{xt}	=	functional health status in age group *x* in year *t*, transformed to a 0 to 1 scale;
l_0	=	starting birth cohort;
Edu_{xt}	=	years of education attained during age group *x* for year *t*;
$Learn_{xt}$	=	average standardized test score in age group *x* for year *t*, transformed to a 0 to 1 scale.

Equation (I.4) gives an index measure of expected human capital for each birth cohort, which is calculated as the expected years lived from age 20 to 64 years and adjusted for educational attainment, learning or education quality, and functional health status using rates specific to each time period, age, and sex for all countries covered by the project. The functional health status combines seven health status outcomes into a single measure using principal components analysis.

It is worth mentioning that uncertainty analysis was undertaken in both the IHME HCI and the WB HCI projects and the corresponding estimated uncertainty in the measure of human capital are reported.

The composite index of the UNDP HDI is compiled as the geometric mean of normalized indices for each of the three dimensions: Health, Education, and Income.

(I.5) $$UN\ HDI = (I_{Health} * I_{Education} * I_{Income})^{1/3},$$

where I_{Health}, $I_{Education}$, and I_{Income} are three normalized dimensional indexes and each of them, with defined minimum and maximum values, is calculated as:

(I.6) $$Dimension\ index = \frac{actual\ value - minimum\ value}{maximum\ value - minimum\ value}.$$

As shown in Equation (I.5), the three dimensions of Health, Education, and Income are equally weighted. On the one hand, such a construction reflects that the UN HDI focuses on the snapshot illustration of the current state of development of a country/economy, in which all the three dimensions are considered equally important.

On the other hand, the UN HDI is distinctively different from the WB HCI and IHME HCI, because the latter two place their focuses on the extent to which education and health can impact on the potential productivity largely as a means, while the UN HDI treat education and health not only as a means but also as an end-in-itself.

It is worth noting that there also exist a variety of UN HDI by taking inequality, gender, and poverty into considerations, such as the Inequality-adjusted Human Development Index (IHDI), Gender Development Index (GDI), Gender Inequality Index (GII), and Multidimensional Poverty Index (MPI). In addition, there are also five Human Development Dashboards which extend to address environmental and socioeconomic sustainability (see UNDP, 2019).

Although not included in a chapter in the forthcoming book, there exists another Global Human Capital Index which has been constructed by the World Economic Forum since 2015 (WEF GHCI hereafter). The latest data based on updated methodologies was published in *The Global Human Capital Report 2017*, covering 130 countries/economies for 2017 (World Economic Forum, 2017).

The WEF GHCI assesses the degree to which countries have optimized their human capital for the benefit of their economies and of individuals' themselves. By emphasizing both employment and education, it provides a means of measuring a country's human capital - both current and expected - across its population. Moreover, it measures the quantifiable elements of countries' talent resources holistically according to individuals' ability to acquire, develop and deploy skills throughout their working life rather than simply during the formative years. Thus, it treats human capital as a dynamic rather than fixed concept.

In addition, the WEF GHCI has a number of subcomponents dependent upon the WEF's Executive Opinion Survey. Another unique feature of the WEF GHCI project is that it measures the skill diversity of recent tertiary graduates with a Herfindahl-Hirschman Index (HHI) of concentration among the broad fields of study. [8]

The composite index of the WEF GHCI is compiled based on four dimensions, for each of them, there is a subindex. The four dimensions are Capacity, Deployment, Development, and Know-how. Each corresponding subindex is constructed by using a number of indicators and following basically the same formula as shown in Equation (I.6). The four thematic subindexes are weighted equally in the aggregate overall GHCI, while the age-group specific data within these subindexes is weighted by population (see World Economic Forum, 2017).

Essentially, the WEF GHCI shares a common feature with the WB HCI, the IHME HCI, and the UN HDI in that the WEF GHCI holds all countries to the same standard, measuring countries' 'distance to the ideal' state, or gap in human capital optimization. To arrive at this score, the Index examines each indicator in relation to a meaningful maximum value that represents 'the ideal'. Every indicator's score is a function of the country's 'distance from the ideal' for the specific dimension measured.

I.3 Comparison of human capital estimates among projects

It is interesting and informative to make some comparisons based on the results from the above-mentioned different human capital projects, both in terms of either the monetary or the index measures and of the rankings thereof. Such comparisons can be implemented by means of correlation analysis which shows whether these measures tend to change together, if yes, to what extent.[9]

To serve the purpose, two frequently applied correlation measures, describing both the strength and the direction of the relationship, will be applied here. One is the Pearson correlation[10], and the other is the Spearman correlation[11]. Both the Pearson and Spearman correlation coefficients have the value range from −1 to +1.

Since the available projects that have been discussed in the forthcoming book and this chapter have different country and year coverage, the comparison will be undertaken between each two of them, based on mutually the same selected countries and in the same, or the closest year.

The first comparison is between the two monetary measures covered, i.e. human capital per capita measure by the World Bank's CWON project compared with that by the IWR project in year 2014. If the comparison was done with total human capital for each country, the rankings could differ as the

[8] The Herfindahl-Hirschman Index (HHI) is a commonly accepted measure of market concentration and is often used to determine market competitiveness. In the WEF GHCI project, the HHI is applied for measuring the concentration of the distribution of graduates among various disciplines (World Economic Forum, 2017).

[9] Another way that the various measures could be compared is to track changes in the measures over time.

[10] The Pearson correlation evaluates the *linear* relationship between two continuous variables. A relationship is linear when a change in one variable is associated with a proportional change in the other variable.

[11] The Spearman correlation evaluates the *monotonic* relationship between two continuous or ordinal variables. In a monotonic relationship, the variables tend to change together, but not necessarily at a constant rate. The Spearman correlation coefficient is based on the ranked values for each variable rather than the raw data.

proportion of the population working can differ by country. CWON estimates the human capital of the working population only, while IWR estimates the human capital of the total adult population. Among the 123 countries compared, the Slovak Republic is the outlier. With the Slovak Republic included, the calculated Pearson correlation is 0.15, albeit positive, but a low value.

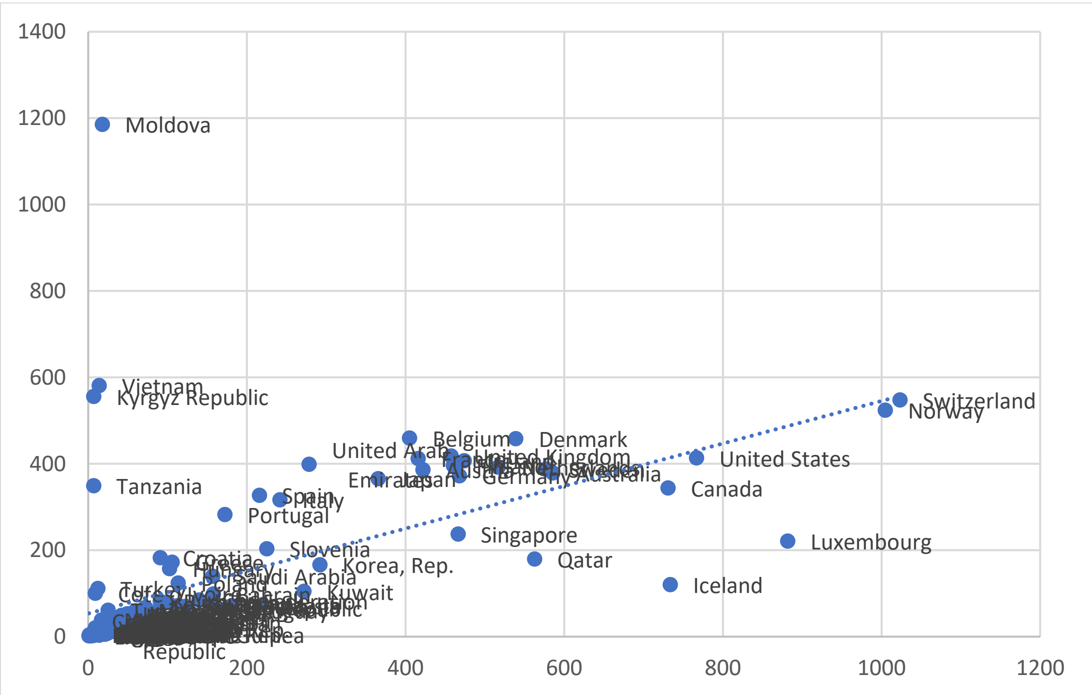
Figure I.1 demonstrates the relationship of the human capital per capita measure between the CWON and the IWR project for 122 countries when the Slovak Republic is removed from the comparison. As visualized, the CWON human capita per capita measures for the majority of the countries covered are higher than their corresponding IWR measures. Moldova is an outlier among the countries shown. Further, without the Slovak Republic, the calculated Pearson correlation has increased substantially from 0.15 to 0.60.

Figure I.2 displays the relationship based on the rankings of the two monetary human capital per capita measures from the CWON and IWR projects. The calculated Spearman correlation, also based on 122 countries, is 0.81, which means that there is a high positive correlation between the two rankings, despite the existence of several outliers, such as Moldova, Vietnam, Kyrgyz Republic, Tanzania, Turkey, and Cote d'Ivoire. In addition to the Slovak Republic, all these countries just mentioned have much higher rankings of human capital per capita in the CWON project than in the IWR project, which merits further investigations.[12]

Note that although the comparison as shown in Figures I.1 and I.2 is carried out based on the same

Figure I.1 Comparison of human capital per capita measure between CWON (2014) and IWR (2014)

CWON measure (X-axis) vs IWR measure (Y-axis) (122 countries, US$ in thousands)

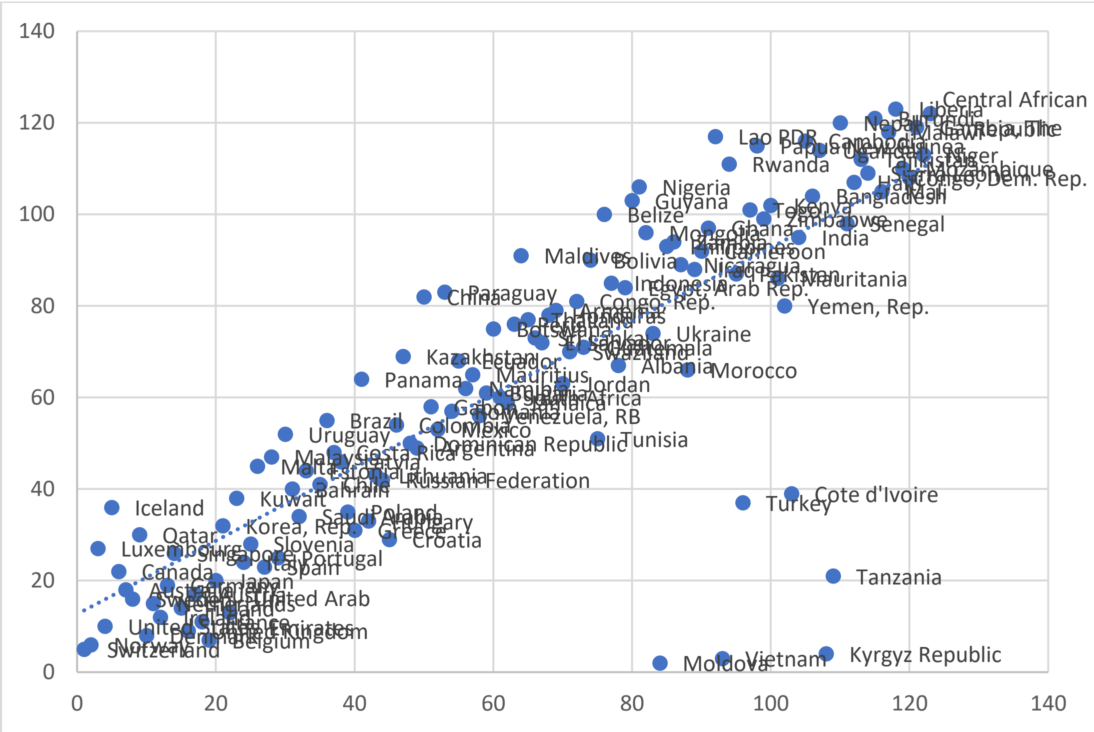


Source: Authors' own calculations. Note: Pearson correlation = 0.60.

[12] Since the value of ranking is given according to the descending order of country human capital per capita, a country with lower value in ranking has actually higher ranking status.

Figure I.2 Comparison of human capital per capita ranking between CWON (2014) and IWR (2014)

CWON ranking (X-axis) vs IWR ranking (Y-axis) (122 countries)



Source: Authors' own calculations. Note: Spearman correlation = 0.81.

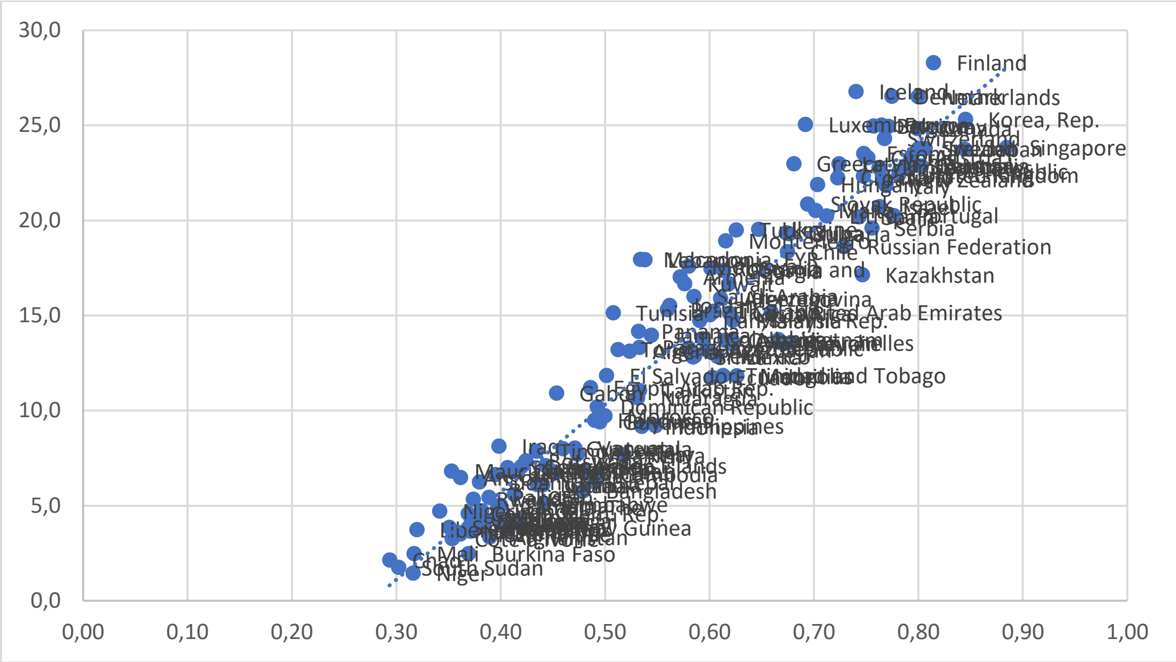
(122) countries and for the same year (2014), the human capital per capita is measured in constant 2014 US$ by means of the market exchange rates in the CWON project, while it is measured in 2005 US$ by using the Purchasing Power Parity (PPP) exchange rates in the IWR project. As a result, the differences between the two monetary measures come from at least two sources: one is the choice of the base year, i.e. 2014 vs. 2005, and the other is the choice of exchange rates, i.e. market exchange rates vs. PPPs. Therefore, if all these issues are taken into consideration and are addressed properly, the comparison results could have been different.[13]

In this Introduction, two human capital measures by applying the indicators-based approach, i.e. the WB HCI and the IHME HCI, are selected for presenting the visual relationship between the two human capital index measures. Figure I.3 and Figure I.4 are based on these two index measures and on the rankings thereof, respectively. As shown, both the calculated Pearson and Spearman correlations are as high as 0.95, based on the selected 151 countries/economies.

Figure I.3 Comparison of human capital index measure between WB HCI (2018) and IHME HCI (2014)

WB HCI measure (X-axis) vs. IHME HCI measure (Y-axis) (151 countries)

[13] There are some differences in the 2014 rankings of these countries in GDP per capita, constant 2010 US dollars used by CWON versus GDP per capita, PPP, constant 2011 international dollars used by IWR.



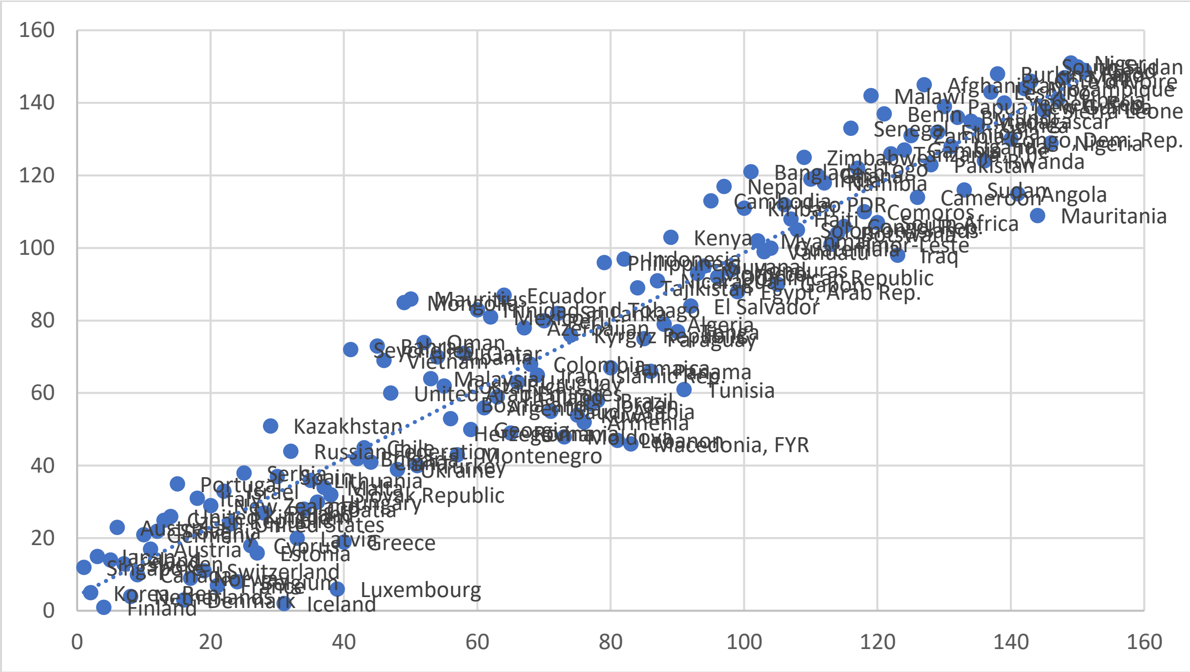
Source: Authors' own calculations. Note: Pearson correlation = 0.95.

In Table I.2, both the Pearson and Spearman correlations among the two monetary and the four indicators-based measures are reported with each other. Note that for data used by the WB HCI, 2018 is the only year available. As for the WEF GHCI, data for 2017 is used. There exist data for 2015, however, the estimating method was quite different from the latest one as applied by the WEF GHCI for 2017.

As shown in Table I.2, the positive correlations are found among different measures of human capital discussed, both in terms of the measures and of the rankings. The range of the calculated Pearson correlation is between 0.27 and 0.95 with the mean equal to 0.70, while the range of the calculated Spearman correlation is between 0.70 and 0.95 with the mean equal to 0.86.

Figure I.4 Comparison of human capital index ranking between WB HCI (2018) and IHME HCI (2014)

WB HCI ranking (X-axis) vs. IHME HCI ranking (Y-axis) (151 countries)



Source: Authors' own calculations. Note: Spearman correlation = 0.95.

Table I.2 Correlation of human capital estimates among international projects in 2014

Pearson/Spearman correlation	CWON	IWR	WB HCI	IHME HCI	UN HDI	WEF GHCI
CWON	-	0.60/0.81 (122)	0.67/0.85 (131)	0.69/0.86 (140)	0.67/0.94 (139)	0.66/0.80 (117)
IWR		-	0.55/0.78 (129)	0.37/0.79 (139)	0.27/0.80 (138)	0.53/0.70 (123)
WB HCI			-	0.95/0.95 (151)	0.94/0.95 (153)	0.89/0.91 (125)
IHME HCI				-	0.93/0.94 (183)	0.86/0.88 (130)
UN HDI					-	0.85/0.87 (129)
WEF GHCI						-

Source: Authors' own calculations.
Notes: 1. Data used by WB HCI and WEF GHCI are for 2018 and 2017, respectively; 2. The number of selected countries/economies for each comparison is in parenthesis.

The ranking correlation (indicated by the Spearman correlation) is not lower than the corresponding level correlation (indicated by the Pearson correlation), with only one exception where the former is slightly lower than the latter between the WB HCI and the IHME HCI. This finding indicates that policy-makings related to human capital based on the rankings might be more suggestive than those based on pure level or index measures.

As also shown in Table I.2, the correlations within the indicators-based measures are higher than within the monetary measures. All the correlations are higher between the CWON measure, than between the IWR measure, and any of the indicators-based measures. In addition, the correlations are higher between each of the WB HCI, the IHME HCI, and the UN HDI, than between the WEF GHCI, and the CWON measure. Moreover, among the indicators-based measures, the correlations between each pair of the WB HCI, the IHME HCI, and the UN HDI are higher than between any of the first three indexes and the WEF GHCI.

Conclusion

The six measures of human capital differ from each other because some are monetary measures and some are indicator-based measures, and their methodologies employed even within these types differ in significant ways. Whether or not the strength of the correlations matter depends on how they are to be used. In any case, individual country results may be particularly important to a consumer of these measures.

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