Creating a Human Capital Model Based on Global Indexes

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Abstract. The purpose of this work is to form a multi-factor model of indicative diagnostics of human capital in relation to GDP per capita based on 15 aggregated global indexes. The study using regression and correlation analysis allowed us to form the innovative human capital index (IHC), focused on predicting GDP per capita, and to determine the complex optimal Predictor for IHC diagnostics. The main components of this Predictor are the Global Competitiveness Index (0.4), Mean Years of Schooling (0.3), GDP per capita (0.15), and Corruption Perception Index (0.05). The regression error of the IHC index with the optimal Predictor is 2% for a sample of 24 major economies and 5.6% is the average value for five samples of 6-72 economies.

Keywords: Correlation; Forecasting; GDP per capita; Global index; Human capital; Regression analysis.

1. Introduction

Human capital (HC) is one of the most important modern socio-economic systems, which contains up to 80% of the world's wealth. The study of HC has become one of the most important areas of economic research. Traditional methods of calculating the value of human capital are focused on obtaining its financial assessment, which allows further including it, along with physical and natural capital, in the equations of economic dynamics [2]. The financial assessment of HC can be obtained by taking into account investments in human capital [8], based on the income received from it [6], or by using the discount method proposed by World Bank. It should be noted that all these methods have a number of significant disadvantages, and estimates of the value of HC using them differ significantly.

The indicator approach is based on the measurement of natural indicators of HC, such as the number of years spent for training of employees [3]. The disadvantage of this method is the use of the average number of training years, although the results of these studies show that with the growth of the training duration, the GDP per capita generated by the corresponding human capital increases exponentially. Consequently, higher levels of education contribute significantly more to the national wealth. Moreover, Badinger & Tondl show that economic growth in different regions of the European Union is only sensitive to tertiary education, and differences in the level of secondary education do not have a statistically significant impact on economic development [1].

The authors of this work have developed a method of indicative diagnostics [12] of the educational component of HC, which takes into account the contribution of various educational levels of HC to GDP growth in more detail. For most countries, it provides a low forecast error, but for some countries with a high educational level (Russia, Israel, and South Korea), the forecast error reaches 40%. This makes it necessary to develop assessment methods that use a wider range of information about human capital.

Due to the importance of the HC concept, several human capital indexes have been developed recently, in particular indexes proposed by the World economic forum [15], and the World Bank [17]. These two HC indexes provide a non-financial score that is not directly related to the number of training years. They estimate HC in fractions of a unit or as a percentage. Accordingly, the question arises how to link these estimates to financial units and/or to the GDP per capita generated by them.

It is also important that significantly different indicators (components) are used to calculate these two indexes. Schwab takes into account mainly the competence of the staff, namely, the education level of employees, their accumulated skills, the growth of educational components and qualifications, as well as skills that are used at work (know-how) [15]. The Human Capital Index focuses mainly on the health of HC and takes into account: the survival rate of employees under the age of 60, the probability of living until the age of 5 for children, the proportion of children without developmental disabilities, and the expected number of school years before the age of 18.

It may seem that Global Human Capital (GHC) indicators look more closely related to the essence of human capital than the Human Capital Index (HCI). However, the regression-correlation analysis gives, in general, a different result [13]. It is possible that there is a hidden predictor that correlates better with HCI. For example, good health care and education can be an important factor in the formation of high-performance human capital, although this factor is not measured, but it is closely related to HCI. Can this be identified and how does it relate to the presence of two alternative HC indexes?

Another question is whether it is possible to predict the HC value determined based on HCI and GHC and using a sufficiently large number of aggregated global indexes, and what is the composition of the corresponding Predictors. Thus, the use of new indexes for evaluating human capital brings with it a significant number of issues that will be explored in this paper. The purpose of this work is to form a multi-factor model of indicative diagnostics of human capital in relation to GDP per capita based on a block of global indexes.

2. Methodology

The methodological basis of this work is a systematic approach. It is used for regression and correlation analysis of the system of socio-economic activity based on human capital, the result of which is GDP per capita (in accordance with purchasing power parity – PPP). The authors use a system of global aggregated indexes presented in Table 1, where, in comparison with the work [9], the following indexes are added: CPI, SPI, LEI and KIG, which is relevant, since the Social Progress Index significantly reduced the regression error with GDP/C.

Table 1. Indexes used in the work

i	Complete Name	Abbreviation
1.	Index of Economic Freedom [5]	IEF
2.	Ease of Doing Business Ranking	EDB
3.	Worldwide Governance Indicators [7]	WGI
4.	Global Competitiveness Index [15]	GCI
5.	Mean Years of Schooling [20]	MYS
6.	R&D Expenditure [9]	ERD
7.	World Happiness Index [4]	WHI
8.	GDP per capita (World Bank)	GDP/C
9.	The Legatum Prosperity Index [10]	LPI
10.	Corruption Perception Index [19]	CPI
11.	The Social Progress Index [16]	SPI
12.	Life Expectancy Index [20]	LEI
13.	KOF Index of Globalization [14]	KIG
14.	Global Human Capital [15]	GHC
15.	Human Capital Index [17]	HCI

Source: authors.

Because of the difficulty of comparing countries that differ significantly in GDP size, a series of samples was used that included a different number of economies ranked by the GDP size. Depending on the number of countries, they were designated: G6, G12, G24, G48, G72. The optimization of GDP/C Predictors was based on the average value of the regression error ($\Delta R^2 = 1-R^2$), which was indicated by the index *m* or *mid*.

Optimal complex Predictors were formed from indexes given in Table 1 by linear composition, with the sum of non-negative weighting coefficients $\Sigma k_i = 1$. Predictors were optimized in order to minimize the average value of the error of the ΔRm^2 regression over five samples using the gradient descent method with cyclic variable replacement.

3. Results

The Global Human Capital approach to measurement allows us to apply it not only to countries, but also to individual corporations, industries, and regions. The Human Capital Index can only be used for larger socio-economic structures such as states or regions. Therefore, it is important to understand their interrelation and areas of application. Considering the statistical dependence of the two human capital indexes on each other, it is shown that the regression error is quite large for them and for the G24 sample is $\Delta R^2 \approx 17\%$. The GHC regression from HCI is approximately linear, GHC values about half as low as HCI. This means that the Human Capital Index differentiates countries significantly more, which is a positive factor. The regression line is weakly dependent on the sample, and the regression error increases with the sample size.

Since the concept of human capital is important in terms of creating national wealth per capita, we will consider the ability of two HC indexes to provide forecasts of GDP per capita (GDP/C), both individually and as part of optimized pair

Predictors. Table 2 shows data on the regression error of the GDP/C dependence on these two indexes (power trend), as well as on the optimal pair Predictors and the complex optimal Predictor CP_1, components of which are given in Table 3.

Table 2. The regression error of the GDP/C from different Predictors, %

	G6	G12	G 24	G48	G 72	mid
GHC	11.3	18.6	18.6	33.5	33.6	23.1
HCI	16.6	11.4	8.9	28.3	22.0	17.4
0.42 GHC+0.58 SPI	4.5	4.1	7.4	18.9	14.6	**9.9**
0.35 HCI+0.65 SPI	7.5	6.2	6.4	17.3	13.2	10.1
Predictor CP_1	2.4	2.6	5.8	13.5	9.9	**6.8**

Source: authors.

Table 3. Components of the optimal complex Predictor for GDP/C

IEF	EDB	GCI	MYS	ERD	WHI	LPI	CPI	SPI	KIG	GHC	HCI
0.03	0.06	0.02	0.12	0.01	0.15	0.04	0.01	0.26	0.07	0.08	0.15

Source: authors.

The dependence of GDP/C on the optimal pair Predictor is shown in Fig. 1. In its structure, the share of human capital (GHC) is 42%. The best results are provided by a power trend with a degree of 4.3, although the exponential and power trends are very close. In Fig. 1, the G6 sample points are marked with special icons – from left to right in Fig. 2: India, China, Russia, USA, Japan, Germany. The point corresponding to Russia (square) is close to the trend line, and the USA (circle) is much higher.

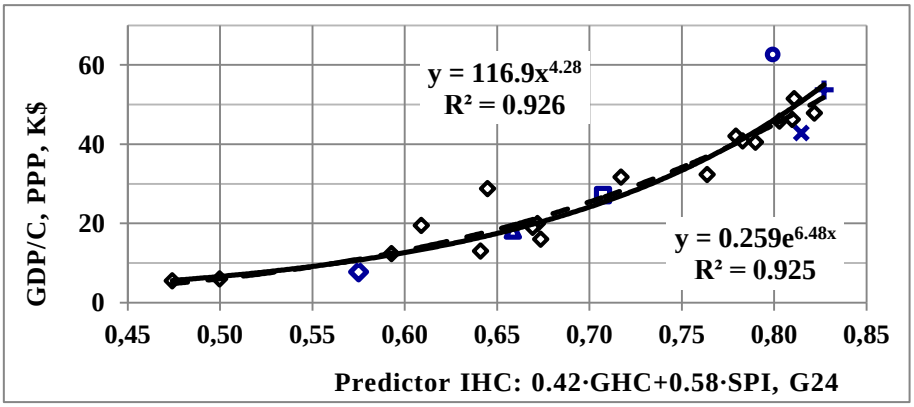

Fig. 1. GDP/C regression from the optimal pair Predictor (Source: authors).

The share of human capital in the optimal complex Predictor is 23%, but the Mean Years of Schooling index [20], whose share is 12%, also reflects characteristic of human capital. Together they contribute 35% to the GDP/C Predictor. However, other indexes that affect GDP/C have components related to the formation of HC too. Thus, the Social Progress Index [16] contains among 12 indicators medical care and nutrition, sanitation and water supply, medicine and health, access to basic and higher education.

Table 2 shows that the regression error of the studied HC indexes varies significantly depending on indexes with which they interact in their impact on GDP/C. To study the influence of other Predictors on the Human Capital Index, it is necessary to create a comprehensive index of HC. Taking into account the obtained data, it can be assumed that the complex HC Index (IHC) can be calculated using the formula (1).

$$IHC = 0.4\ GHC + 0.6\ HCI \quad (1)$$

This index characterizes the relative quality of human capital. In order to calculate the total value of the country's HC, you need to multiply the IHC by the number of employees. On average, the share of the employed population in the 20 largest economies is 44% [18]. Since HC is implemented not only in production, we can assume that the number of people who make up human capital is equal to half of the population of countries. Corresponding to this approximation, the values of the number of HC for the largest economies are shown in Fig. 2.

It is characteristic that this dependence is well approximated by the hyperbolic equation (R^2 = 0.96). China's human capital is 23% of the world's, Russia's is 2.5%, and the US – 6.2%. This definition of human capital rather characterizes the intellectual development potential of countries. In market conditions, the accumulated scientific and technological potential and competitive position in the markets are very important. All this affects the amount of GDP (and GDP/C) that countries receive.

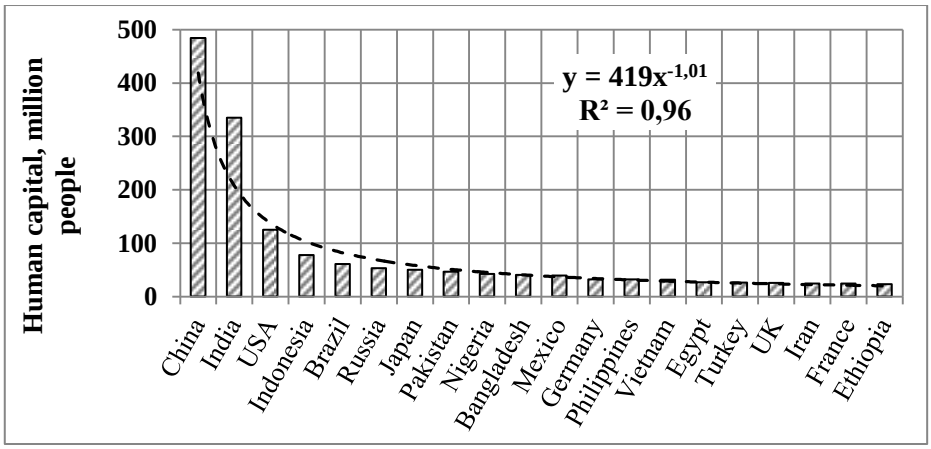

Fig. 2. Number of human capital in the largest economies (Source: authors).

Let’s consider factors affecting the human capital index. In order to find out what Predictors and how they affect the complex Human Capital Index (1), we first determine the IHC regression error from each of the indexes listed in Table 1 individually. The corresponding results with a trend in the form of a cubic polynomial are shown in Table 4 (for all samples, except G6, a quadratic polynomial is sufficient). The lowest regression error is provided by the GDP/C indexes (ΔR^2 = 11%) and MYS (14%).

Table 4. The error of IHC regression from global indexes, %

	G6	G12	G24	G48	G72	mid		G6	G12	G24	G48	G72	mid
IEF	0.8	53	40	47	47	38	GDP/C	0.7	6.8	7.2	22	19	**11**
EDB	11	26	28	32	39	27	LPI	15	26	14	18	15	17
WGI	17	18	29	36	33	27	CPI	0.2	28	14	9	36	18
GCI	10	17	13	22	20	16	SPI	0.9	25	12	26	21	17
MYS	3.7	11	11	24	20	**14**	LEI	14	30	18	25	27	23
RDE	12	34	29	15	39	26	KIG	6.7	23	21	29	25	21
WHI	1.7	46	54	49	45	39							

Source: authors.

Table 5 shows the regression error for the best optimal Predictors paired with GDP/C and MYS. It can be seen that the Global Competitiveness Index has the strongest impact on human capital in pairs [15]. Thus, the regression error of the Predictor 0.4×MYS+0.6×GCI was ΔR^2 = 6.2%, which is almost half as much as that of the best individual index of influence on human capital – GDP/C, for which ΔR^2 = 11%. It should be noted that the GCI, in addition to indicators of economic competitiveness, also contains components characteristic for human capital: health, education and the labor market.

Table 5. Error of IHC regression from paired Predictors, %

Pairs		k8/k5	G6	G12	G24	G48	G72	mid
GDP/C	EDB	0.8	0.5	4.7	5.4	19.7	16.8	9.4
	GCI	0.6	0.6	3.9	3.6	18.2	15.3	**8.3**
	LPI	0.65	0.1	7.8	5.2	17.2	14.5	9.0
	CPI	0.9	0.0	4.7	5.8	21.9	17.8	10.0
	LEI	0.8	0.2	7.1	7.1	19.6	16.8	10.2
	KIG	0.8	1.1	7.4	6.9	19.8	16.8	10.4
MYS	EDB	0.75	3.4	9.3	4.8	17.0	13.3	9.6
	GCI	0.4	0.9	3.2	2.9	13.5	10.7	**6.2**
	ERD	0.7	1.3	3.0	7.0	17.5	13.2	8.4
	CPI	0.7	1.1	2.5	5.5	18.2	14.8	8.4

Source: authors.

Fig. 3 shows the dependence of IHC on the optimal pair Predictor with a quadratic trend for the G24 sample. It is characteristic that with the growth of the Predictor above the value of 0.8, IHC goes to the "shelf" as a result of the growth of the negative quadratic term. In figure 1, we saw that GDP/C is growing like a fourth-degree polynomial. Thus, in order of magnitude, GDP/C will grow proportionally to the square of the paired Predictor linearly associated with Mean Years of Schooling [20].

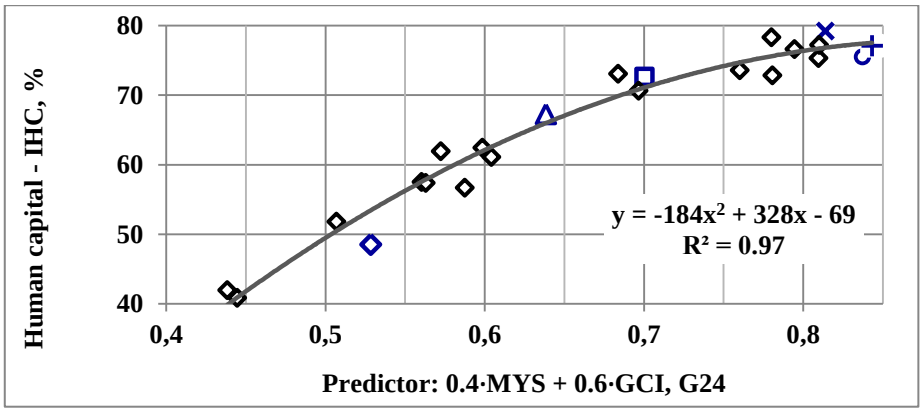

Fig. 3. IHC Regression from the optimal pair Predictor for G24, % (Source: authors).

Obtaining the characteristics of the IHC regression index with paired Predictors allows us to search for the optimal complex Predictor – CP for human capital. Optimization was performed by varying k_i coefficients and search for their values that provide the minimum average of the regression error values for five samples. The obtained optimal values of CP coefficients are shown in Table 6.

Table 6. Components of the optimal complex Predictor for IHC

Weighting coefficients	k_2	k_4	k_5	k_6	k_7	k_8	k_{10}	k_{12}
Indexes	EDB	GCI	MYS	ERD	WHI	GDP/C	CPI	LEI
Optimal values	0.03	0.4	0.3	0.02	0.03	0.15	0.05	0.02

Source: authors.

Figure 4 shows the regression dependence of IHC on the optimal complex Predictor CP for the G24 sample.

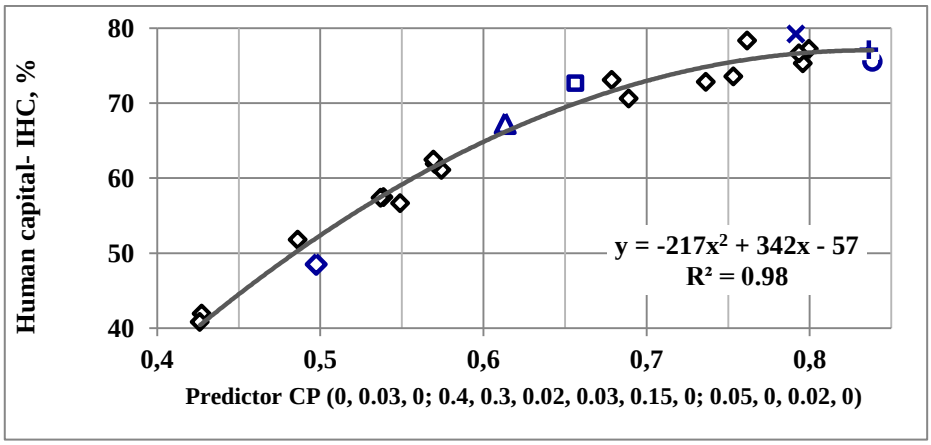

Fig. 4. IHC Regression from the complex Predictor CP, G24 (Source: authors).

It can be seen that, in comparison with the optimal pair Predictor, the regression error for G24 decreased by one and a half times (from 3% to 2%), and for the average of five samples from 6.2% to 5.6%. As in the best paired Predictors, the Global Competitiveness Index, Mean Years of Schooling, and GDP per capital indexes occupy a key place in the complex Predictor (85% in total). The regression line is also quadratic with an output "on the shelf". According to this Predictor, the IHC human capital score is 3% above the trend line.

4. Discussion

In connection with the development of the World Bank [17] and the World Economic Forum [15] two alternative human capital indexes (HCI and GHC, respectively), which are fundamentally different from each other and from the methods of assessing human capital that were used previously. A number of questions and opportunities arose in connection with the use of these unique tools.

The difference between these two indexes can be interpreted as a fact that one or both of them are incorrect to varying degrees. At the same time, the argument that HCI is aimed at assessing the future HC is not very convincing, since for it the error of synchronous regression with GDP/C is significantly less than for GHC. However, the presence of two indexes allows them to form Predictors on a statistical basis and in combination with other global indexes for more accurate forecasting of GDP/C, on the one hand, and the formation of a model for indicative diagnostics of human capital, on the other.

Comparison of these two indices and statistical estimation of their regression with GDP/C allowed us to propose a total IHC index aimed at predicting the value of GDP/C. The HCI and GHC indices characterize the relative quality of human capital, but they can be used to estimate the absolute size of human capital of different countries, which is very important from the point of view of investors' understanding of labor markets.

The presence of such a total index of human capital also allowed us to form a model of indicative diagnostics of human capital. Somewhat unexpected was the result of the analysis, which showed that indexes related to human capital do not dominate in the impact on the value of GDP/C and a significant contribution is made by World Happiness Index and Social Progress Index, although they also have components related to HC. Another unexpected aspect was that the strong impact on of Global Competitiveness Index on the human capital index (IHC). These results require additional research, in particular, using the method of cognitive modeling, since it is clear that in such a complex, weakly structured system, the relations are quite complex and nonlinear. Additional research is also needed on the fact that IHC's dependence on the Predictor of human capital is "on the shelf", since this may contradict the results of Mincer [11], according to which labor results depend exponentially on the number of training years.

5. Conclusion

Regression and correlation analysis of the impact of 14 global indexes on GDP per capital allowed us to form the IHC human capital index, which is focused on forecasting GDP per capita, and to determine the complex optimal Predictor for IHC diagnostics.

It is shown that, according to the IHC, the largest human capital in the world (in millions of people) is possessed by: China (484), India (335), the USA (125), Indonesia (76), Brazil (61), Russia (53) and Japan (50).

The optimal pair Predictor for IHC includes Mean Years of Schooling (0.4) and Global Competitiveness Index (0.6). The regression error ($\Delta R^2 = 1-R^2$) for it is less than 3.2% for samples that do not exceed 24 countries, and 6.2% is the average value for samples from 6, 12, 24, 48 and 72 samples.

The main components of the optimal complex Predictor are the Global Competitiveness Index (0.4), Mean Years of Schooling (0.3), GDP per capita (0.15), and Corruption Perception Index (0.05). The regression error of the IHC index with the optimal Predictor is 2% for a sample of 24 major economies and 5.6% - the average value for five samples of 6-72 economies.

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