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**Article**

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# METHODOLOGICAL APPROACH TO IDENTIFICATION OF INNOVATIVE DETERMINANTS OF HUMAN CAPITAL MANAGEMENT

**Abstract**. *This article summarizes the arguments and counter-arguments in the scientific discussion on identifying the essential characteristics of human capital and key quantitative indicators of its evaluation. The article determined the evolutionary patterns of changing approaches to interpreting the essence of human capital. The study's main purpose is to form an integrated indicator of human capital assessment and identify the most relevant innovative drivers and inhibitors of its development. Systematization of literature sources and approaches to solving the human capital evaluation problem has shown a significant variation in both national approaches to solving the problem and their supranational counterparts. Given the lack of a unified approach to evaluating human capital, the article proposes an author's approach to solving the problem using the Fishburne formula and additive convolution. The relevance of the selection of normalized partial indicators to the integrated indicator is confirmed based on the Cronbach's alpha test. The composite human capital evaluation indicator includes several social, economic, and institutional indicators. Given the transformation of all components of the business environment and the national economy due to the formation of Industry 4.0, it is necessary to determine the most relevant innovative factors of human capital development. A sample of potential drivers and inhibitors of impact on the composite indicator of human capital evaluation, which have an innovative nature, is formed to achieve this goal. The panel data regression model was built. All calculations were performed using Stata 12/SE software product. Modeling results showed that most determinants of innovation development do not have a statistically significant impact on Human Capital Index and vice versa. Human Capital Index is positively influenced by information and communication technology exports but negatively influenced by the imports of computers, communications and services, and high-tech exports. At the same time, the growth of the Human Capital Index has a negative impact on the growth of the share of exports of computers, communications, and services in the structure of commercial imports and high-tech exports. The study results could be useful to scientists, public authorities, local governments, businesses, and entrepreneurs.*

**Keywords:** human capital, innovative determinants, management, panel data, regression modeling.

**Introduction.** Research on the nature of human capital formation and identifying drivers and inhibitors of its change is an important area of research and practical work. It could identify promising ways to

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increase labor productivity, ensure economic growth, and create a basis for the qualitative transformation of society and the economic system.

Scholars have focused on the research of the development and management of human capital since 1940-1950, but this subject area has experienced rapid development in the XXI century. Approaches to understanding the nature of human capital have changed from more primitive interpretations, in which human capital was understood as the ability to use skills and competencies to ensure social and economic benefits, to a more comprehensive understanding of this concept (UNECE, 2016). In a modern and generally accepted context, human capital is defined as "the knowledge, skills, competencies, and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being" (OECD, 2001).

There are different approaches to measuring human capital, which is based on the cost approach, investment approach, knowledge-based approach, etc. In addition, scientists determined that human capital depends on several educational, migration, institutional, and health care factors (UNECE, 2016). Approaches to the assessment of human capital vary both in terms of different research and national approaches. The Human Capital Index is calculated by the World Bank Group (World Bank DataBank, 2022) only from 2018, which does not allow its use in empirical studies with a long time series of observations. Therefore, forming an integrated indicator of human capital evaluation and identifying the most relevant innovative drivers and inhibitors of its development is an important and urgent task.

**Literature Review.** Identification of substantive and evolutionary patterns of development of the «human capital» concept is proposed to be carried out based on trend analysis. The basis for this analysis is the nearly 32,000 publications on relevant issues published in Scopus journals. It is worth noting that the earliest Scopus article in this subject area is (Westoby, 1947), in which the author highlighted a new vision of the impact of education on the future earnings of employees and provided a new interpretation of the concept of «human capital».

However, the latest Scopus publication on this issue (Montanaro et al., 2022) focused on identifying the determinants (including the characteristics of human capital) that define the «exit value of European venture capital». The study is based on statistics from 107 European companies from 2010 to 2017. The authors empirically confirmed the hypothesis of a positive relationship between exit value and qualitative characteristics of the human capital of the company's founders (education, professional experience).

Because during 1947-1969 it was published only about 20 Scopus articles, the analysis of publishing dynamics is proposed to be considered for 1970-2022 (Figure 1).

According to Figure 1, it could be noted certain evolutionary and temporal patterns of research in this direction, namely: during 1970-1989, there was a moderate interest of scientists in studying the development of human capital (on average during the year in this period published about 30 articles on relevant topics). On the other hand, it could be considered 1990-2005 as a period of the progressive development of publishing activity in this field (about 290 articles are published annually on average). While 2006-2021 is characterized by the dynamic development and rapid growth of the intensity of publications on relevant topics. Thus, an average of more than 1590 articles were published annually. It is also worth noting that the study of various aspects of human capital development in 2021 was devoted to 2879 Scopus publications, while according to the forecast based on the polynomial trend till the end of 2022 it should be published 2887 articles in this area (on June 1, 2022, it has been already published 1250 Scopus articles on human capital).

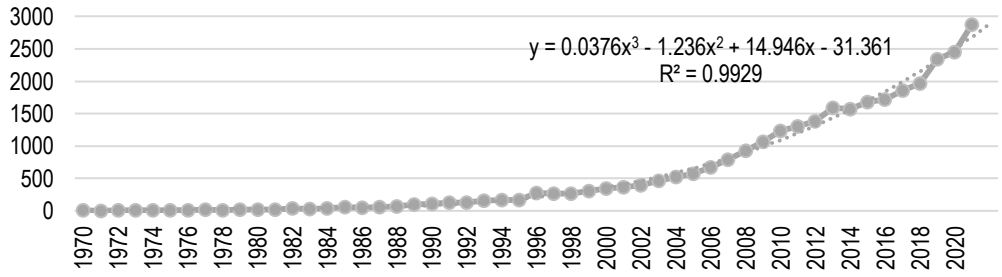


**Figure 1. Dynamics of Scopus publications on human capital issues during 1970-2022 (forecasted)**

Sources: developed by the authors based on the Scopus data (2022).

For a more accurate and comprehensive understanding of human capital research's substantive and evolutionary patterns, it is worth considering the most cited publications on this topic (Table 1).

**Table 1. TOP-10 the most cited Scopus publications on human capital issues**

| № | Document title | Authors | Year | Source | Cited by |
|---|---|---|---|---|---|
| 1 | On the mechanics of economic development | Lucas Jr., RE | 1988 | Journal of Monetary Economics 22 (1), pp. 3-42 | 9971 |
| 2 | Endogenous technological change | Romer, PM | 1990 | Journal of Political Economy 98 (5), pp. S71-S102 | 9821 |
| 3 | Projections of global mortality and disease burden from 2002 to 2030 | Mathers, CD, Loncar, D. | 2006 | PLoS Medicine 3 (11), pp. 2011-2030 | 7171 |
| 4 | Economic growth in a cross-section of countries | Barro, RJ | 1991 | Quarterly Journal of Economics 106 (2), pp. 407-443 | 5415 |
| 5 | How does a foreign direct investment affect economic growth? | Borensztein E., De Gregorio, J., Lee, J.-W. | 1998 | Journal of International Economics 45 (1), pp. 115-135 | 2508 |
| 6 | The lifelong effects of early childhood adversity and toxic stress | Shonkoff JP, Garner, AS, Siegel, BS, (...), Weitzman C., Wegner, LM | 2012 | Pediatrics 129 (1), pp. e232-e246 | 2490 |
| 7 | The role of social and human capital among nascent entrepreneurs | Davidsson, P., Honig, B. | 2003 | Journal of Business Venturing 18 (3), pp. 301-331 | 2478 |

**Continued Table 1**

| № | Document title | Authors | Year | Source | Cited by |
|---|---|---|---|---|---|
| 8 | Income distribution and macroeconomics | Galor, O., Zeira, J. | 1993 | Review of Economic Studies 60 (1), pp. 35-42 | 1764 |
| 9 | Smart cities in Europe | Caragliu , A., del Bo, C., Nijkamp, P. | 2011 | Journal of Urban Technology | 1661 |
| 10 | The human resource architecture: Toward a theory of human capital allocation and development | Glue, DP, Snell, SA | 1999 | Academy of Management Review | 1647 |

Sources: developed by the authors based on the Scopus data (2022).

Lucas (1989) considered human capital in the traditional sense through schooling. The scholar described the development model of specialized human capital, which involves practice-oriented learning. Despite innovative ideas in work, the author focuses only on the educational component of human capital, ignoring other essential components.

Romer (1990) continued the above vector of human capital research. The author focused on identifying the relationship between human capital and economic growth. In particular, the author empirically confirmed that the quality of human capital is the key to economic growth. Still, the quantitative existence of a significant amount of human resources does not necessarily ensure high economic growth rates. Thus, the researcher emphasized the need for the qualitative development of human capital rather than a quantitative increase in the workforce.

Mathers and Loncar (2006) predicted the mortality rate by 2030. In this study, the authors consider human capital as one of the factors influencing the studied performance variable. It is worth noting that the authors define human capital as the «average number of years of schooling of the population above the age of 25».

Barro (1991) examines the relationship between economic growth and human capital. According to the modeling results, it is established that there is a positive relationship between these variables.

Authors Borensztein et al. (1998) confirmed that the positive return on foreign direct investment increases significantly if a sufficient level of human capital development is achieved.

Shonkoff et al. (2012) revealed medical, social, and biological patterns of influence of early childhood experience on the development of human capital.

Davidsson and Honig (2003) investigated the role of human capital in the development of start-up entrepreneurs. In particular, it was found that «human capital in predicting entry into nascent entrepreneurship, but only weakly for carrying out the start-up process towards successful completion».

In turn, Galor and Zeira (1993) investigated the return on investment in human capital development. The authors concluded that the asymmetry of information, capital market development and different macroeconomic preconditions determine the effectiveness of the return on investment in human capital and identify differences in wealth and income distribution.

Caragliu et al. (2011) studied the role of human capital in urban development. In particular, researchers have found that the level and quality of education of labour resources is one of the essential prerequisites for the well-being of cities.

Lepak and Snell (1999) studied the architecture of human capital formation as a determinant of corporate structure development.

It is also necessary to analyse the most recent publications to understand the newest perspective

research on human capital.

Van den Heuvel et al. (2022) analyzed the relationship between employee financial wealth and chances for early income mobility. Through the analysis of young specialists from Belgium, the authors concluded that employees with higher initial financial wealth might find a job that meets their human capital perspective. Otherwise, young employees with low initial financial wealth might agree to work in a position that underestimates their human capital characteristics.

Gómez-Valenzuela (2022) explored the relationship between human capital proxies and company performance in the Dominican Republic. Authors found out that human capital plays a crucial role in business performance, especially in «manufacturing and in-services firms».

In turn, Piao and Managi, (2022) focused on the research of stress impact on human capital losses. While analyzing more than 1 million cases of employee stress in 390 Japanese companies in 2017–2019, authors revealed that stress negatively impacts human capital value (it decreases approximately $0.6 million USD by retirement for male employees aged 25 years).

Zhang et al. (2022) found out that the quality of human capital in China significantly depends on investment in health insurance programs. Authors also noted that investment in medical insurance might be preferable for young employees.

Chang and Wu (2022) researched the relationship between political regimes and human capital development. Under the analysis of more than 80 authoritarian regimes that existed from 1970 to 2010, authors revealed that higher government spending on education might lower a probability of a fall of an authoritarian regime.

Thus, the analysis results revealed that researchers had devoted many studies to identifying the relationship between different socio-economic parameters and human capital. However, only a few studies focused on identifying innovative drivers and inhibitors of its development, which determines the need for more in-depth scientific research.

**Methodology and research methods.** This study aims to identify innovative drivers and inhibitors of human capital management. This task would be performed based on panel data regression modeling using the Stata 12/SE software.

All empirical calculations involved the open data from the World Bank collections (World Bank DataBank, 2022), specifically, World Development Indicators and Education Statistics. The study sample includes 12 European and Asian countries (Azerbaijan, Armenia, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Poland, Romania, and Ukraine). The time range of observations is 2006-2020.

At that first stage, it is necessary to create a Human Capital Index, which is a dependent variable of the model. The literature review showed that human capital is regarded as a multifaceted phenomenon that considers education, health, migration, and other processes. It should be noted that this study rests on the assumption that the improvement of human capital depends on increased investment in education, health care, life expectancy, and the workforce's education. Thus, to form the Human Capital Index, it is proposed to use the following indicators:

- Government expenditure on education, total (% of government expenditure) (GE_Ed);
- Domestic general government health expenditure (% of general government expenditure) (GE_H);
- Life expectancy at birth, total (years) (LE);
- Capital expenditure as % of total expenditure in public institutions (%) (CE_Ed);
- Enrolment in tertiary education, all programs, both sexes (number) (Enr_ter);
- Inbound mobility rate, both sexes (%) (In_mob);
- Labor force with advanced education (% of the total labor force) (LF_AE).

To bring the indicators to a comparable form, their normalization was carried out by dividing the actual value of the indicator by the maximum value for the entire geographical sample. The normalization method

is suitable for this set of statistics, as they are all stimulants - increasing their value positively affects human capital. Considering the assumption that human capital dimensions, which are selected in the paper, have no the same-scale significance in the Human Capital Index. Therefore, it is necessary to identify their weight coefficients.

Thus, the next step is to determine the significance of each of the indicators and their integration. This research stage aims to clarify the scale of the impact of the partial indicators (human capital dimensions) on the integral indicator (dependent variable) based on the combination of principal component analysis and the Fishburne formula. Principal component analysis might help to reveal the significance of human capital dimensions and form a background for their ranking. In contrast, the Fishburne formula would help to integrate differently-weighted partial indicators in Human Capital Index.

It is proposed to use the principal components analysis to determine the importance of human capital development indicators. Thus, it is necessary to identify the optimal number of principal components that should be taken into account based on the scree plot (the principal components that explain most of the variation of the HCI). Next, it is needed to calculate the arithmetic mean of the absolute eigenvalues of the indicators from each of the selected principal components. The next step is to rank the calculated eigenvalues and assign them a rank (the lowest rank is assigned to the indicator with the lowest eigenvalue). Based on the results of ranking eigenvalues, the weights of partial indicators are determined using the Fishburne formula. The final step of this study stage is the formation of the Human Capital Index using additive convolution (Formula 1).

$$HCI = w1 \cdot GE_{Ed} + w2 \cdot GE_H + w3 \cdot LE + w4 \cdot CE_{Ed} + w5 \cdot Enr_{ter} + w6 \cdot In_{mob} + w7 \cdot LF_{AE} \quad (1)$$

where $HCI$ – Human Capital Index; $GE_{Ed}$ – Government expenditure on education, total (% of government expenditure; $GE_H$ – Domestic general government health expenditure (% of general government expenditure); $LE$ – Life expectancy at birth, total (years); $CE_{Ed}$ – Capital expenditure as % of total expenditure in public institutions (%); $En_{ter}$ – Enrolment in tertiary education, all programs, both sexes (number); $In_{mob}$ – Inbound mobility rate, both sexes (%); $LF_{AE}$ – Labor force with advanced education (% of the total labor force); *w1-w7* – weight coefficients calculated based on a complex combination of Principal Component Analysis and Fishburne formula.

In order to confirm the internal consistency of the partial indicators selected for the Index, it is also proposed to perform a Cronbach's alpha test.

The next stage of the study is to identify the innovative drivers and inhibitors of human capital management. Thus, the study tested the impact of such determinants of innovation activity on the Human Capital Index as:

- the ratio of ICT goods to total goods exports (Ex_ICT);
- the ratio of computer, communications, and other services to commercial service imports (Im_CCS);
- the ratio of computer, communications, and other services to commercial service exports (Ex_CCS);
- the ratio of high-technology exports to manufactured exports (Ex_HT);
- the ratio of medium and high-tech manufacturing value-added to manufacturing value added (VA_MHT);
- Patent applications, non-residents (Non_p);
- Patent applications, residents (Res_p).

In order to identify the innovative dimensions' influence on the dependent variable (Human Capital Index) and vice versa, the panel data regression model was conducted using the panel data regression

modeling module in Stata 12/SE. It is used Random-effects GLS regression. Model specification (random effects) is clarified based on the Hausman test. The test showed Prob>chi2=0.065. Consequently, it allowed concluding that the random-effect model is preferable. This study analyzed not only the impact of innovation and technological development parameters on human capital but also the opposite relationships. That forms a more comprehensive view of innovative human capital management features.

**Results**. Therefore, to fulfill the task set in this work, firstly, it is necessary to determine the general patterns of variation of the selected statistical indicators (Table 2).

**Table 2. Descriptive Statistics**

| Variable | Observations | Mean value | Standard Deviation | Minimum value | Maximum value |
|---|---|---|---|---|---|
| Ex_ICT | 179 | 2.908 | 3.529 | 0 | 13.05 |
| Im_CCS | 176 | 35.808 | 16.634 | 7.73 | 71.69 |
| Ex_CCS | 176 | 30.039 | 16.851 | 3.75 | 69.92 |
| Ex_HT | 158 | 10.312 | 8.416 | 1.02 | 43.43 |
| VA_MHT | 168 | 23.679 | 12.617 | 2.37 | 47.13 |
| Non_p | 172 | 278.378 | 643.083 | 1 | 2872 |
| Res_P | 176 | 871.869 | 1162.232 | 20 | 4676 |
| GE_H | 168 | 8.789 | 2.658 | 2.75 | 14.46 |
| LE | 180 | 72.96 | 2.602 | 66.15 | 78.65 |
| CE_Ed | 111 | 8.893 | 5.496 | 0 | 36.05 |
| Enr_ter | 159 | 597000 | 735000 | 45773.42 | 2850000 |
| In_mob | 156 | 3.132 | 2.271 | 0.1 | 11.7 |
| LF_AE | 87 | 79.162 | 5.273 | 57.22 | 85.86 |

Sources: developed by the authors.

Table 2 shows that some values of indicators are omitted, but in general, the panel is strongly balanced. Thus, it allows for obtaining adequate results of regression modelling.

The next stage of this study is the formation of the Human Capital Index, which involves the principal components analysis in the Stata 12/SE software. Table 3 presents the first stage of this process. Thus, the cumulative variation of the integrated indicator is explained by seven principal components. However, the five principal components explain the most significant variation of the integrated indicator. In contrast, the principal components 6 and 7 have no significant predictive value (determined by the scree plot method).

**Table 3. Principal components/correlation**

| Component | Eigenvalue | Difference | Proportion | Cumulative |
|---|---|---|---|---|
| Comp1 | 1.980 | 0.242 | 0.283 | 0.283 |
| Comp2 | 1.738 | 0.406 | 0.248 | 0.531 |
| Comp3 | 1.332 | 0.498 | 0.190 | 0.722 |
| Comp4 | 0.834 | 0.351 | 0.119 | 0.841 |
| Comp5 | 0.483 | 0.030 | 0.069 | 0.910 |
| Comp6 | 0.453 | 0.273 | 0.065 | 0.974 |
| Comp7 | 0.180 | 0.000 | 0.026 | 1.000 |

Sources: developed by the authors.

Given these findings, the next step uses only the eigenvalues of the partial indicators of the principal components 1-5 (Table 4).

**Table 4. Principal components (eigenvectors)**

| Variable | Comp1 | Comp2 | Comp3 | Comp4 | Comp5 | Average Comp1-5 | Rank | Weight |
|---|---|---|---|---|---|---|---|---|
| GE_Ed | -0.257 | 0.489 | -0.262 | -0.437 | 0.618 | 0,4126 | 6 | 0,250 |
| GE_H | 0.525 | 0.287 | -0.124 | 0.134 | -0.174 | 0,2488 | 1 | 0,042 |
| LE | 0.443 | -0.198 | 0.496 | 0.169 | 0.585 | 0,3782 | 5 | 0,208 |
| CE_Ed | -0.520 | -0.094 | 0.128 | 0.601 | 0.315 | 0,3316 | 3 | 0,125 |
| Enr_ter | 0.269 | -0.561 | -0.294 | -0.320 | 0.320 | 0,3528 | 4 | 0,167 |
| In_mob | 0.009 | 0.309 | 0.714 | -0.355 | -0.068 | 0,2910 | 2 | 0,083 |
| LF_AE | 0.346 | 0.469 | -0.239 | 0.417 | 0.199 | 0,3340 | 3 | 0,125 |

Sources: developed by the authors.

Thus, the calculated arithmetic mean of the eigenvalues of partial indicators of human capital created a background for identifying the importance of each individual indicator in the integral. In particular, the higher the calculated value of the arithmetic mean of eigenvalues, the more significant is this individual indicator and vice versa. At the next stage, each partial indicator is assigned a rank. The lower significance of the indicator is, the lower its rank is. It is worth noting that such indicators as «Capital expenditure as % of total expenditure in public institutions (%)» and «Labour force with advanced education (% of the total labour force)» have almost identical values of the arithmetic mean of the eigenvalues. Therefore, these individual indicators are assigned the same «3» rank.

In the next step, this study is determined the weights within the Human Capital Index as the ratio of the rank of a particular partial indicator to the sum of the ranks of all partial indicators. The Human Capital Index is constructed using the additive convolution according to Formula (2):

$$HCI = 0{,}25 \cdot GE_{Ed} + 0{,}042 \cdot GE_H + 0{,}208 \cdot LE + 0{,}125 \cdot CE_{Ed} + 0{,}167 \cdot Enr_{ter} + 0{,}083 \cdot In_{mob} + 0{,}125 \cdot LF_{AE} \quad (2)$$

where $HCI$ – Human Capital Index; $GE_{Ed}$ – Government expenditure on education, total (% of government expenditure; $GE_H$ – Domestic general government health expenditure (% of general government expenditure); $LE$ – Life expectancy at birth, total (years); $CE_{Ed}$ – Capital expenditure as % of total expenditure in public institutions (%); $Enr_{ter}$ – Enrolment in tertiary education, all programs, both sexes (number);$In_{mob}$ – Inbound mobility rate, both sexes (%); $LF_{AE}$ – Labour force with advanced education (% of the total labour force).

Moreover, the relevance of the selection of partial indicators to the Human Capital Index was also further confirmed based on the Cronbach's alpha test (Table 5). Test results showed that all partial indicators explain a 67.5 % variation of composite indicator (Human Capital Index). Therefore, the consistency of the partial indicators might be considered sufficient.

**Table 5. Cronbach's alpha test results**

| Variable | Observations | Sign | alpha |
|---|---|---|---|
| GE_Ed | 168 | + | 0.652 |
| GE_H | 168 | + | 0.634 |
| LE | 180 | + | 0.642 |
| CE_Ed | 111 | + | 0.649 |
| Enr_ter | 159 | + | 0.731 |
| In_mob | 156 | + | 0.722 |
| LF_AE | 87 | + | 0.692 |
| Test scale | | | **0,675** |

Sources: developed by the authors.

Figure 2 presents the dynamics of the Human Capital Index in 12 sample countries. Thus, most countries are characterized by a reduction in the level of the analysed indicator in 2020.

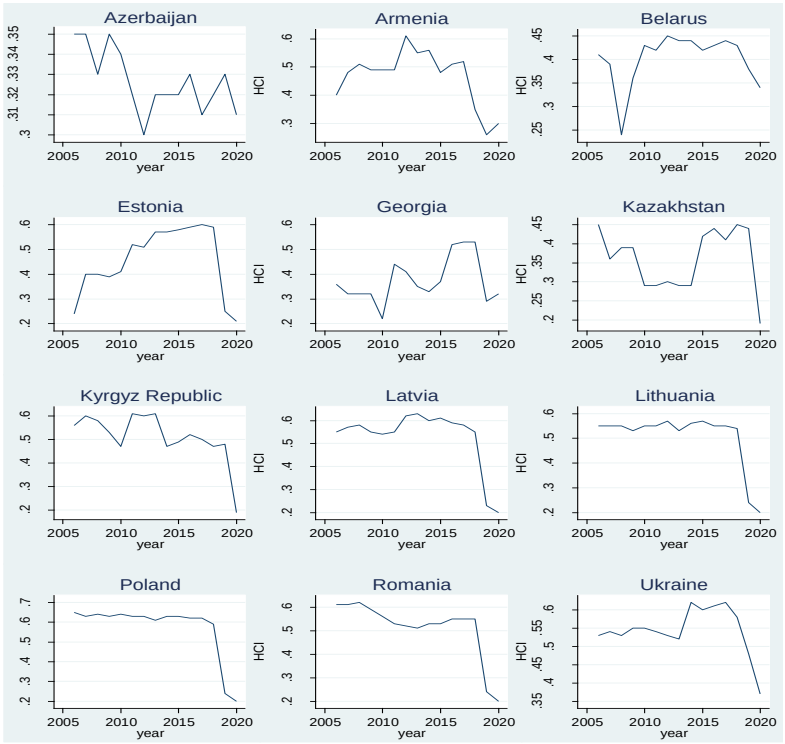


**Figure 2. Dynamics of Human Capital Index (HCI)**

Sources: developed by the authors.

It could be explained by the destructive effects of the coronavirus pandemic during this period. In particular, the widespread coronavirus infection has led to significant transformations in various perspectives of socio-economic life. First, there is a deterioration in the quality and stability of the educational process due to the distance learning format. In addition, the coronavirus pandemic has led to an overburdening of the healthcare system and the need to reallocate financial resources from other sectors to the healthcare system. During the pandemic, the migratory activity of the labour force and education seekers was significantly limited. Taking into account the levels of the Human Capital Index and using hierarchical clustering, it was found three clusters within this group of countries according to the level of the analysed indicator: the first cluster includes Azerbaijan, Belarus, and Georgia; the second – Kazakhstan, Kyrgyzstan, and Ukraine; third – the rest countries. It is also fair to note that the first cluster unites the countries with the lowest level of human capital, the second – with slightly higher, and the third – with more progressive European countries.

The next stage of the study is to determine the relationship between the Human Capital Index and the determinants of innovation development. Tables 6-12 present the results of the panel data regression modelling. In particular, according to the modelling results (Model 1), the growth of ICT exports of goods by 1% with a 90% confidence probability leads to an increase in the Human Capital Index by 0.008 units. It is also worth noting that no statistically significant vice versa relationships exist.

**Table 6. Regression results (Model 1)**

| Variable | Coefficient | St. Error | t-value | p-value | 95% Confidence Interval | | Sig |
|---|---|---|---|---|---|---|---|
| | | | EX_ICT → HCI | | | | |
| EX_ICT | 0.008 | 0.004 | 1.76 | 0.078 | -0.001 | 0.016 | * |
| Constant | 0.443 | 0.024 | 18.39 | 0.000 | 0.395 | 0.490 | *** |
| | | | HCI → EX_ICT | | | | |
| HCI | 0.807 | 1.004 | 0.80 | 0.421 | -1.161 | 2.776 | |
| Constant | 2.518 | 1.011 | 2.49 | 0.013 | 0.536 | 4.501 | ** |

Sources: developed by the authors.

The strongest and most statistically significant relationship was found in model 2 (Table 7). Thus, a 1% increase in the import share of computers, communications, and services in the structure of commercial imports with a 99% confidence probability leads to a decrease in the Human Capital Index by 0.004 units. An increase of HCI in 1 unit leads to a reduction in the share of such imports by 21.88%.

**Table 7. Regression results (Model 2)**

| Variable | Coefficient | St. Error | t-value | p-value | 95% Confidence Interval | | Sig |
|---|---|---|---|---|---|---|---|
| | | | Im_CCS → HCI | | | | |
| Im_CCS | -0.004 | 0.001 | -4.13 | 0.000 | -0.006 | -0.002 | *** |
| Constant | 0.603 | 0.041 | 14.69 | 0.000 | 0.523 | 0.684 | *** |
| | | | HCI → Im_CCS | | | | |
| HCI | -21.884 | 4.681 | -4.67 | 0.000 | -31.059 | -12.709 | *** |
| Constant | 46.059 | 5.128 | 8.98 | 0.000 | 36.007 | 56.110 | *** |

Sources: developed by the authors.

Table 8 shows that the change in the share of exports of computers, communications, and services in the structure of commercial exports does not have a statistically significant effect on the variation of the Human Capital Index. Still, such a relationship is relevant in the opposite direction. In particular, a 1 unit HCI increase leads to a 16.72% reduction in the export share of computers, communications, and services in the structure of commercial exports.

Thus, the growth of the Human Capital Index has a negative impact on the dynamics of exports and imports of computers, communications, and services. However, in this context, it is important to emphasize that such a negative relationship may be relevant only in the short term (within one year, without time lags). In the long run, this relationship could likely change the sign to the opposite.

**Table 8. Regression results (Model 3)**

| Variable | Coefficient | St. Error | t-value | p-value | 95% Confidence Interval | | Sig |
|---|---|---|---|---|---|---|---|
| | | | Ex_CCS → HCI | | | | |
| Ex_CCS | -0.001 | 0.001 | -1.26 | 0.207 | -0.003 | 0.001 | |
| Constant | 0.497 | 0.033 | 15.12 | 0.000 | 0.433 | 0.561 | *** |
| | | | HCI → Ex_CCS | | | | |
| HCI | -16.723 | 5.682 | -2.94 | 0.003 | -27.860 | -5.586 | *** |
| Constant | 37.959 | 4.799 | 7.91 | 0.000 | 28.553 | 47.364 | *** |

Sources: developed by the authors.

It is also worth noting that the relationship between the Human Capital Index and high-tech exports (Table 9) is very similar to the previous Model 2.

**Table 9. Regression results (Model 4)**

| Variable | Coefficient | St. Error | t-value | p-value | 95% Confidence Interval | | Sig |
|---|---|---|---|---|---|---|---|
| | | | Ex_HT → HCI | | | | |
| Ex_HT | -0.003 | 0.002 | -1.51 | 0.101 | -0.007 | 0.001 | * |
| Constant | 0.493 | 0.031 | 15.97 | 0.000 | 0.433 | 0.554 | *** |
| | | | HCI → Ex_HT | | | | |
| HCI | -4.293 | 2.677 | -1.60 | 0.100 | -9.541 | 0.954 | * |
| Constant | 12.321 | 2.757 | 4.47 | 0.000 | 6.917 | 17.725 | *** |

Sources: developed by the authors.

**Table 10. Regression results (Model 5)**

| Variable | Coefficient | St. Error | t-value | p-value | 95% Confidence Interval | | Sig |
|---|---|---|---|---|---|---|---|
| | | | VA_MHT → HCI | | | | |
| VA_MHT | 0.000 | 0.001 | 0.35 | 0.726 | -0.002 | 0.003 | |
| Constant | 0.467 | 0.042 | 11.21 | 0.000 | 0.385 | 0.549 | *** |
| | | | HCI → VA_MHT | | | | |
| HCI | -1.084 | 3.427 | -0.32 | 0.752 | -7.801 | 5.633 | |
| Constant | 24.198 | 4.014 | 6.03 | 0.000 | 16.331 | 32.066 | *** |

Sources: developed by the authors.

**Table 11. Regression results (Model 6)**

| Variable | Coefficient | St. Error | t-value | p-value | 95% Confidence Interval | | Sig |
|---|---|---|---|---|---|---|---|
| | | | Non_p → HCI | | | | |
| Non_p | 0.000 | 0.000 | 1.10 | 0.270 | 0.000 | 0.000 | |
| Constant | 0.455 | 0.025 | 18.44 | 0.000 | 0.406 | 0.503 | *** |
| | | | HCI → Non_p | | | | |
| HCI | 59.923 | 95.824 | 0.63 | 0.532 | -127.889 | 247.735 | |
| Constant | 241.177 | 192.221 | 1.25 | 0.210 | -135.570 | 617.923 | |

Sources: developed by the authors.

**Table 12. Regression results (Model 7)**

| Variable | Coefficient | St. Error | t-value | p-value | 95% Confidence Interval | | Sig |
|---|---|---|---|---|---|---|---|
| | | | Res_p → HCI | | | | |
| Res_p | 0.000 | 0.000 | 0.82 | 0.410 | 0.000 | 0.000 | |
| Constant | 0.453 | 0.026 | 17.54 | 0.000 | 0.402 | 0.503 | *** |
| | | | HCI → Res_p | | | | |
| HCI | -90.207 | 261.944 | -0.34 | 0.731 | -603.607 | 423.192 | |
| Constant | 910.731 | 339.758 | 2.68 | 0.007 | 244.817 | 1576.644 | *** |

Sources: developed by the authors.

Summarizing the regression modelling results (Tables 10-12) indicates that the Human Capital Index does not depend on value-added and patent activity changes and vice versa.

**Conclusions.** The study of the nature and evolution of the concept of human capital development dates back to 1947 (when the first Scopus publication was published in this subject area). The evolution of research on human capital could be divided into several periods: 1) 1947-1969 – the emergence of scientific research in this direction; 2) 1970–1989 – a period of moderate interest of scientists in the study of human capital development; 3) 1990–2005 – progressive development of publishing activity; 4) 2006–2022 – dynamic development of scientific research in the field of human capital management.

Created in the paper based on a complex combination of the Principal Components Analysis,

Fishburne formula, and additive convolution, the Human Capital Index takes into account financial, educational, migration, and health determinants. According to the level of this indicator, the 12 countries of the sample could be divided into three clusters: the lowest level of the indicator is characterized by Azerbaijan, Belarus, and Georgia; slightly higher – by Kazakhstan, Kyrgyzstan, and Ukraine; the highest levels of human capital development are in Latvia, Lithuania, Estonia, Poland, Romania, and Armenia.

The results of the panel data regression modelling found that in the absence of time lags, most determinants of innovation development do not have a statistically significant impact on HCI and vice versa. At the same time, the simulation results confirm the positive impact of the growth of ICT exports on the Human Capital Index and the negative impact on the growth of the share of imports of computers, communications, and services in the structure of commercial imports and high-tech exports. At the same time, the growth of HCI has a negative impact on the growth of the share of exports of computers, communications, and services in the structure of commercial imports and high-tech exports.

As a prospect for further research, it is advisable to test the interaction of the above indicators but subject to the existence of time lags of this impact. It is assumed that the Human Capital Index would be much more positively dependent on the determinants of innovation development in the long run.

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**Методологічні засади визначення інноваційних детермінант управління людським капіталом**

Ця стаття узагальнює аргументи та контраргументи в рамках наукової дискусії щодо питання ідентифікації сутнісних характеристик людського капіталу та виявлення основних кількісних індикаторів його оцінювання. У статті визначено еволюційні закономірності зміни підходів до трактування сутності людського капіталу. Основною метою дослідження є формування інтегрального показника оцінювання людського капіталу та виявлення найбільш релевантних інноваційних драйверів та інгібіторів його розвитку. Систематизація літературних джерел та підходів до вирішення проблеми оцінювання людського капіталу засвідчила, що існує значна варіація як національних підходів до вирішення поставленого завдання, так і їх наднаціональних аналогів. Враховуючи відсутність уніфікованого підходу до оцінювання людського капіталу, у статті запропоновано авторський підхід до вирішення поставленого завдання з використанням формули Фішберна та адитивної згортки. Релевантність відбору попередньо нормалізованих часткових індикаторів до інтегрального показника підтверджено на основі тесту альфа Кронбаха. Композитний індикатор оцінювання людського капіталу включає ряд показників, що мають соціальну, економічну та інституціональну природу. Враховуючи трансформацію усіх компонентів бізнес-середовища та національної економіки, обумовлених становлення Індустрії 4.0, актуальності набуває необхідність визначення саме інноваційних факторів розвитку людського капіталу. Для досягнення поставленого завдання буде сформовано вибірку потенційних драйверів та інгібіторів впливу на композитний індикатор оцінювання людського капіталу, що мають інноваційну природу. З метою реалізації поставленого завдання автором побудовано регресійну модель на панельних даних. Усі розрахунки проведено за допомогою програмного продукту Stata 12/SE. Результати моделювання показали, що більшість детермінант інноваційного розвитку не мають статистично значимого впливу на індекс людського капіталу, і навпаки. Тим не менш, індекс людського капіталу позитивно впливає на експорт інформаційно-комунікативних технологій, але негативно впливає на імпорт комп'ютерів, комунікацій та послуг, а також експорт високотехнологічних товарів. Водночас зростання індексу людського капіталу негативно впливає на зростання частки експорту комп'ютерів, комунікацій та послуг у структурі комерційного імпорту та високотехнологічного експорту. Результати проведеного дослідження можуть бути корисними науковцям, органам державної влади та місцевого самоврядування, бізнес-структурам та підприємцям.

**Ключові слова:** людський капітал, інноваційні детермінанти, менеджмент, панельні дані, регресійне моделювання.