

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/372203618>

Investment Strategy for the Development of Human Capital of the Enterprise

Article in WSEAS TRANSACTIONS ON BUSINESS AND ECONOMICS · July 2023

DOI: 10.37394/23207.2023.20.134

CITATIONS

0

READS

77

6 authors, including:



Iryna Mykolaichuk
State University of Trade and Economics

23 PUBLICATIONS 17 CITATIONS

SEE PROFILE



Pavlenko Olena
Oles Honchar Dnipro National University

6 PUBLICATIONS 0 CITATIONS

SEE PROFILE

Investment Strategy for the Development of Human Capital of the Enterprise

VIKTORIA BORSHCH

Odesa National Medical University,
65000 Valikhovsky lane, 2, Odesa,
UKRAINE

OLEH SHEREMET

National University of Food Technologies,
01033 Volodymyrska str., 68, Kyiv,
UKRAINE

IRYNA MYKOLAICHUK

State Trade and Economics University,
02000, Kyoto str., 19, Kyiv,
UKRAINE

BASHUK HANNA

«Kryvyi Rih Fahovy Medical College» of Dnipropetrovsk Regional Council,
50051 Medichna str., 14, Kryvyi Rih, Dnipropetrovsk region,
UKRAINE

PAVLENKO OLENA

Dnipro National University the name of Oles Honchar,
49000 Gagarina avenue, 72, Dnipro,
UKRAINE

MYKHAYLO DANILKO

Academician Yuriy Bugay International Scientific and Technical University,
02000 Mahnitogorsky Lane, 3, Kyiv,
UKRAINE

Abstract: - The development of human capital has become increasingly important for enterprises in the context of global transformations, where the parameters of human capital development are influenced by various factors in the external and internal environment. The purpose of this study is to substantiate the theoretical and applied principles of forming an investment strategy for the development of the human capital of the enterprise. The results of the study made it possible to establish that the development of human capital of the enterprise takes place in the context of global transformations, as a result of which the parameters of human capital development are influenced by factors of the external environment and internal environment. The most significant of them is the number of investments in human resources, the involvement of innovations, and the improvement of the professional qualities of personnel. Overall, the results of this study highlight the importance of forming an investment strategy for the development of human capital of an enterprise that takes into account external and internal factors, such as the number of investments in human resources, innovation, and professional development. By investing in human capital, enterprises can improve their competitive position, adapt to changes in the market, and achieve sustainable growth.

Key-Words: - investment, Human Development Index, human capital, investment, competitiveness, innovative development

Received: February 26, 2023. Revised: June 23, 2023. Accepted: June 30, 2023. Published: July 7, 2023.

1 Introduction

The structural restructuring of the economy and the society, reinforced by the emergence of new destabilizing factors in the development of the external and internal environment and the military resistance to the armed aggression of the Russian Federation, have given rise to the aggravation of the issue of effective functioning of enterprises, institutions, and organizations, as a result of which their competitiveness is constantly reduced and the uncertainty of their future existence increases. Ensuring the dynamic development of business entities of various forms of ownership is one of the priority directions for the formation of strategic vectors to provide their development, stability of operations, and the achievement of high profitability indicators. In the conditions of globalization and the strengthening of mega-regionalization, an effective tool for achieving the desired results is the strategic planning of the development of the enterprise's human capital and the formation of an effective internal company policy of its systematic and continuous investment. Taking into account the outlined trends, in current conditions, the issue of investigating the investment strategy for the development of the human capital of the enterprise is actualized, which requires in-depth study.

The purpose of the research is to substantiate the theoretical and applied principles for the formation of an investment strategy for the development of the human capital of the enterprise.

2 Literature Review

Ensuring competitiveness and the formation of competitive advantages at the stage of the enterprise's functioning is one of the priority directions of the business entity's activity. It is the human capital that plays a significant role in this process, because, according to the viewpoint of [1], it can create such competitive advantages that make it possible to successfully implement strategic development targets. Human capital combines the totality of knowledge available to personnel, their professional abilities, and managerial effectiveness. It is worth noting that the ability to attract innovations depends on the level of development of the enterprise's human capital. It is obvious that human capital within the functioning of a business entity turns into a key factor in stimulating the

development of the company; consequently, it is important to finance it in time and meet existing requirements. The outlined theory has been proven and substantiated in the studies of [1], where a close interrelationship between the indicators of the competitiveness of enterprises and the human development index across the countries of the world was established.

[2], adhere to a similar position; they have established that human capital is valuable, and it is an important component of the implementation of innovative strategies, as well as a driving force for improving the effectiveness of the business entity. Along with this, scientists argue that the human capital management system should be consistent with the goals and structure of the development strategy of the enterprise itself, and also provide for the possibility of forming investment strategies.

[3], suggests considering two categories of human capital: (1) general and (2) specific. Moreover, the scientist associates general human capital with the availability of basic education and initial practical experience of employees and identifies specific human capital with knowledge, skills, and abilities to carry out activities in a specific field. It becomes obvious that it is the presence of specific human capital in the company that gives grounds for testing innovations and moving to the principles of innovative and sustainable development of the enterprise.

At the same time, [4], are convinced that the development of human capital is important not only for the implementation of innovations but also for the introduction of strategic projects of the enterprise, which require certain additional resources that can be obtained through investment. The opinion of scientists is shared by [5], who connects the theory of human capital development with constant investment in human resources and believes that the introduction of innovations is more efficient and effective when the organization has powerful modern human capital.

Along with this, [6], considers human capital to be the key to the competitiveness of the company and its stable development. Complementing Pelinescu, the scientific discussion in the given direction, [7], has concluded that the sustainable development of human capital contributes to the economic growth not only of the enterprise but also of the entire country. Therefore, the scientist proposes to carry out further investigations by

comparing indicators of human capital development and innovation and investment development at the level of the whole country with indicators of foreign countries, which will allow identifying common features and problematic aspects, one of which, according to her viewpoint, is the interdependence of low volumes of investment in human capital and the slowdown in economic growth.

At the same time, as noted by [8], the issue of the long-term impact of human capital on current innovations and the stable development of the company requires in-depth study, forasmuch as it has been established that the factor of regionalization has a significant impact on it, which involves the uneven development of regions, its significant disparities and the possibility of ensuring various conditions for economic activity.

Particular attention should be paid to the scientific developments of [9], who argues that ensuring high competitiveness indicators for highly developed countries depends significantly on investment in the development of human capital. Developing this idea, [10], proves that enterprises invest in human capital to improve their performance results. However, scientists are convinced that in the modern scientific discourse, investigations in the direction of studying the issues of the investment strategy for the development of human capital are quite limited, which requires additional exploratory work.

In this context, the observations of [11], are justified; the scholars have proven the need for strategic management of human capital development, which consists of the perception of human capital as one of the elements of the company's assets, forasmuch as it is a sustainable competitive advantage and a factor in the efficiency and effectiveness of the enterprise's activities. However, [12], argues that it is impossible to ensure the sustainable development of human capital without investing in human capital; consequently, each company should develop its investment strategy for the development of human capital. From among the most significant and often implemented investments in the development of human capital, [13], single out such as the systematic training of employees, advancing their level of education, and improving knowledge and skills that influence the enterprise's effectiveness. Under such conditions, mechanisms for promoting investment in human capital development, which, according to the viewpoint of [14], should be divided into public and private ones, become of particular importance.

Taking into account the existing scientific approaches to the issues of human capital

development of the enterprise, it is worth highlighting the urgent necessity for the formation of an investment strategy to ensure its implementation.

3 Research Method

The methodological base of the research was formed using both special and scientific methods of economic analysis and other fundamental investigations, namely: the methods of analysis, synthesis and scientific abstraction were used to identify the essence of the scientific category "human capital", its development features and significance; the methods of system analysis, comparison and analogy were used to carry out applied studies of existing trends in the development of human capital and its impact on indicators of competitiveness and innovative activity of economic entities; by applying the method of comparative analysis, the study of the features of investing in the development of human capital was carried out; methods of generalization and systematization were applied to form conclusions based on the results of the research of the issues outlined; cluster analysis based on the k-means method was used to group the countries of the European Union according to indicators of the Human Development Index, the Global Competitiveness Index, and the Global Innovation Index; graphical and tabular methods made it possible to visually display the applied results of the conducted research.

The countries of the European Union were chosen for the research.

The information base of the research is based on the reporting data of leading international organizations for 2018-2021, namely: Human Development Report according to the human development index indicator; the Global Competitiveness Index according to the global competitiveness index indicator, the Global Talent Competitiveness Index according to the talent competitiveness index and the Global Innovation Report according to the global innovation index.

4 Result

The growing role of human capital in the modern world is driven by its value and significant development potential, not only in the current period but also in the long shot. It becomes obvious that the stable development of the human potential of business entities is a priority task and the driving force of intellectual and technological progress, which depends on the level of competitiveness of the enterprise and its ability to attract innovations.

It should be stated that the existing development tendencies of the world countries do not have stability and uniformity; after all, they position different opportunities for the population to get access to education, acquire professional skills, and implement existing opportunities. As a result, the outlined features cause a discrepancy between human potential and the needs of the economy, and economic entities are not able to provide high levels of competitiveness.

In analyzing the effectiveness of using human potential in modern conditions, it is necessary to take into account the influence of the innovation factor and the level of attracting investment resources to stimulate its development. Some indicators have been developed at the international level, which allows for determining the state of human capital development across countries of the world and conducting comparative correlation in various analyzed groups. One of these important indicators is the Global Competitiveness Index, which makes it possible to assess the state of functioning of enterprises in the country and the efficiency of using human capital. The dynamics of the Global Competitiveness Index in the countries of the European Union for the period 2018–2021 [15], [16], [17], [18], is reflected in Figure 1.

According to the results of the research conducted, the highest indicators of the Global Competitiveness Index are observed in such countries as Finland (GCI: 79–82), the Netherlands (GCI: 72–82), and Denmark (GCI: 72–81); however, the lowest ones are recorded in Greece (GCI: 45–63), Cyprus (GCI: 46–66), Malta (GCI: 47–69), Hungary (GCI: 46–65) and Croatia (GCI: 46–62), which unequivocally proves the uneven level of development of human capital and the efficiency of its user. At the same time, it is worth noting that

significant differences exist in the countries of the European Union regarding the investment of human capital, which is manifested in the amount of funding for the development of human resources in enterprises. As a result, this significantly affects the formation of knowledge, skills, and motivation of employees. It is obvious that in those countries where the amount of investment in the development of human capital is lower and there are no strategies for its implementation, there is a problem of leaving competitive, highly educated, and capable employees outside the country and carrying out activities on the territory of foreign countries, as a rule, highly developed ones. This thesis is confirmed by the indicators of the Talent Competitiveness Index; it is expedient to demonstrate the dynamics of the European Union's states in 2020–2021 in Figure 2.

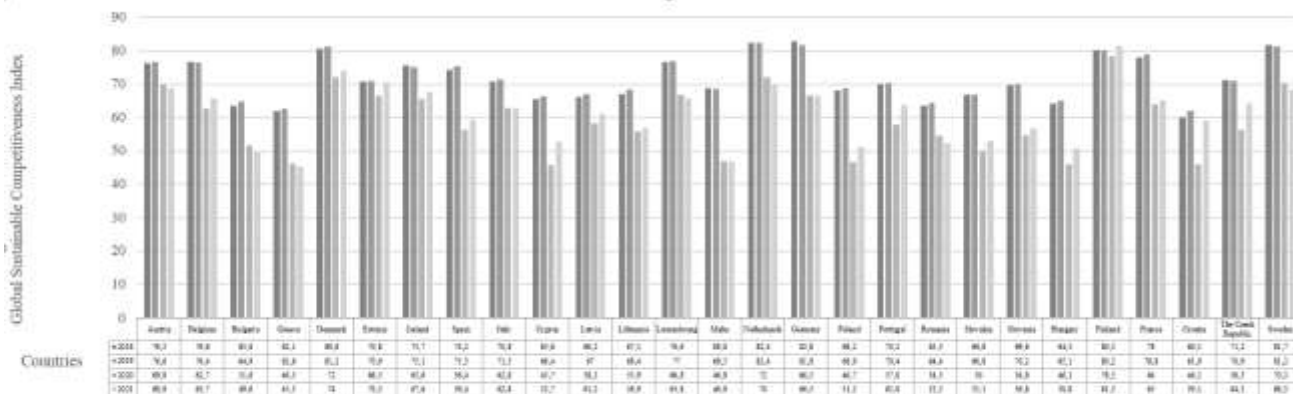


Fig. 1: The state and tendencies of changes in the Global Competitiveness Index in the countries of the European Union in 2018–2021
 Compiled based on: [15], [16], [17], [18]

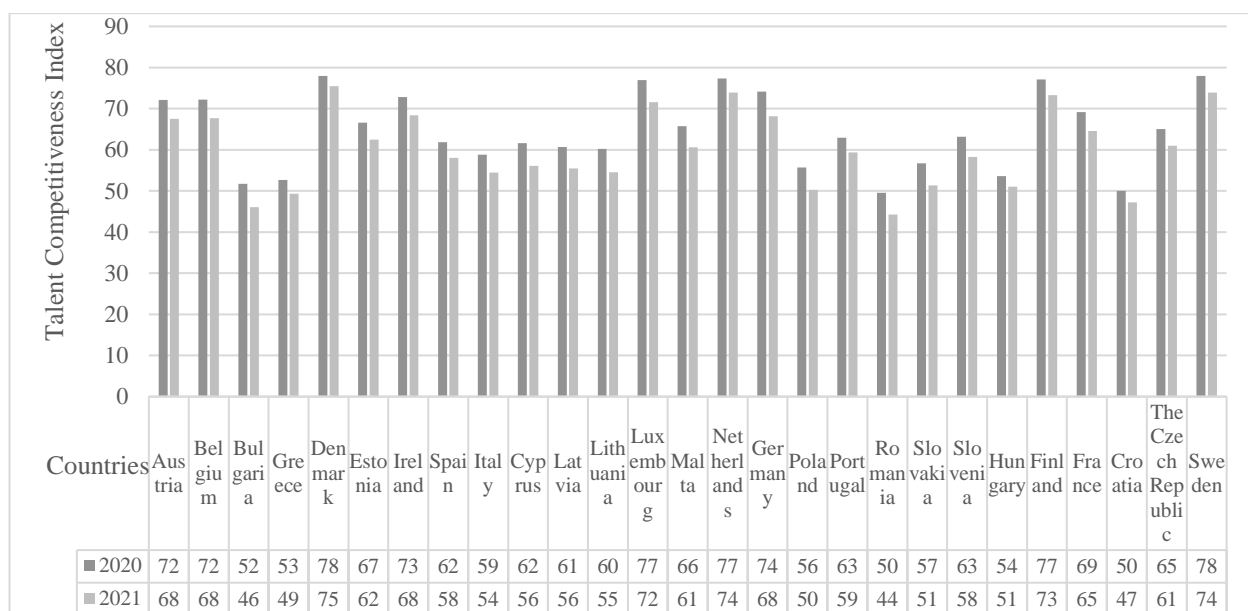


Fig. 2: The state and tendencies of changes in the Talent Competitiveness Index in the countries of the European Union in 2020–2021
Compiled based on [19], [20]

The results of applied studies make it possible to state that according to the Talent Competitiveness Index, the leading positions are held by such countries as Denmark (TCI: 75–78), Luxembourg (TCI: 72–77), the Netherlands (TCI: 74–77), Finland (TCI: 73 –77) and Sweden (TCI: 74–78), and outsiders are Croatia (TCI: 47–50), Romania (TCI: 44–50), Bulgaria (TCI: 46–52) and Greece (TCI: 49–53), respectively. Accordingly, it is possible to state the substantiation of the proposed hypothesis, forasmuch as it has been established that highly developed countries provide higher indicators of talent competitiveness, which indicates a higher efficiency of human capital management.

After all, the investigation of human capital in the system of economic development of a certain country allows analyzing the state of development of human capital according to such criteria as the standard of living of the population, its education, literacy, and life expectancy. As a result of the analysis, it has been established that in terms of the level of human capital development, the highest indicators are positioned in the following countries, namely: Ireland (HDI: 0,94–0,95), Germany (HDI: 0,94), Denmark (HDI: 0,93–0,95), the Netherlands (HDI: 0,93–0,94), Austria (HDI: 0,91–0,92), Finland (HDI: 0,92–0,94), Belgium (HDI: 0,92–0,94), Luxembourg (HDI: 0,90–0,93), Slovenia (HDI: 0,90–0,92) and Sweden (HDI: 0,93–0,95). At the same time, the lowest values of the analyzed indicator have been revealed in Bulgaria (HDI: 0,80–0,82) and Romania (HDI: 0,81–0,82), respectively.

When studying the development of human capital in the countries of the European Union, it is expedient to pay attention to the indicators of the implementation of innovative activities by economic entities. After all, the innovative type of human capital development indicates the attraction of investment resources for its improvement and effective use.

At the international level, it is customary to use the Global Innovation Index for such assessments, which makes it possible to provide insight into the level of balancing of the real needs of the economy and the capabilities of human capital to involve innovations in practical activities. The conducted studies of the dynamics of the Global Innovation Index in the countries of the European Union in 2018–2021 (Figure 4) give grounds to assert that the most innovative enterprises are located in the territory of such countries as Sweden (GII: 62–64), the Netherlands (GII: 59–63) and Finland (GII: 57–60). On the other hand, the lowest indicators in the analyzed group of countries have been recorded in Romania (GII: 36–38), Greece (GII: 36–39), and Croatia (GII: 37–41). The state and tendencies of changes in the Human Development Index in the countries of the European Union in 2018–2021 are shown in Figure 3.

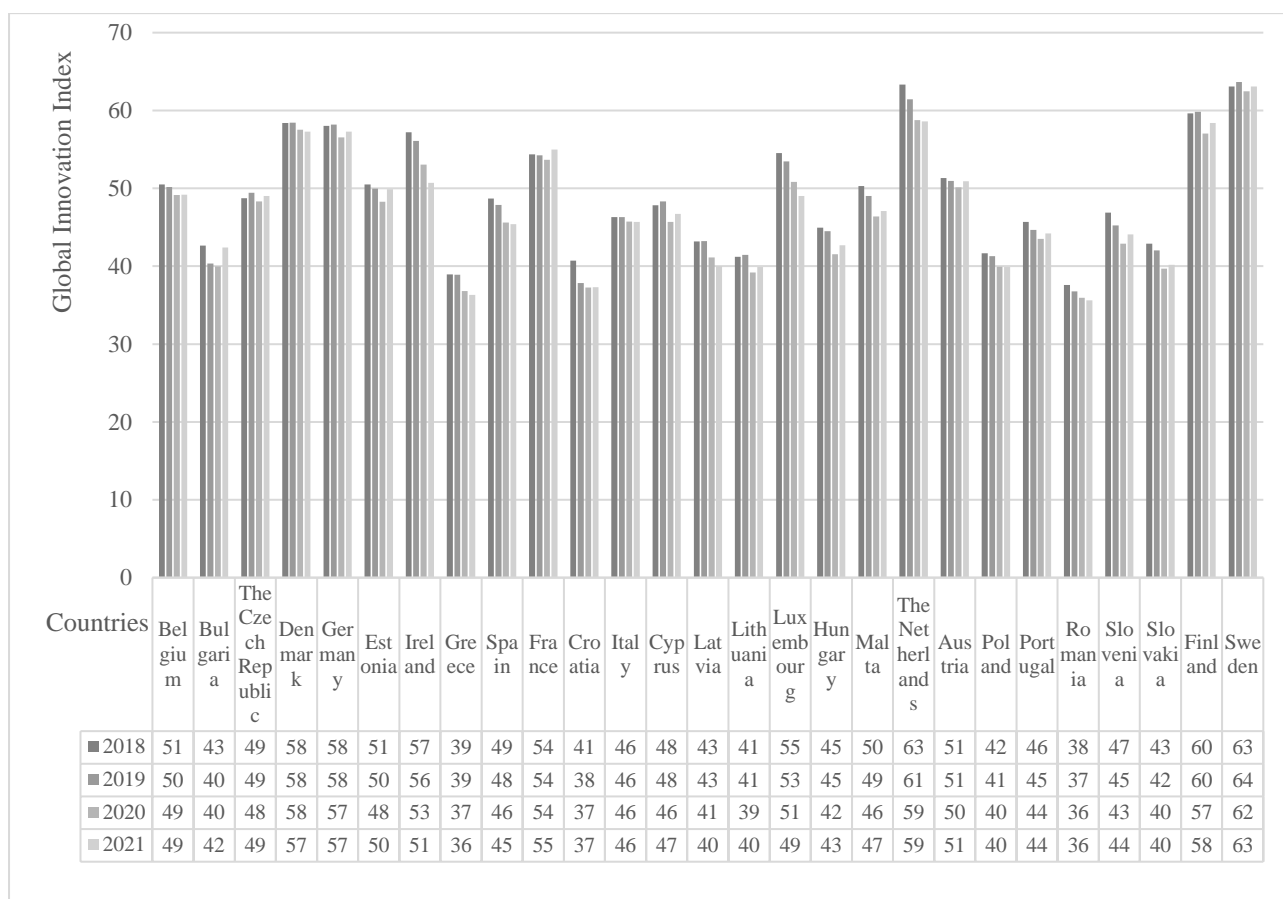


Fig. 4. The state and tendencies of changes in the Global Innovation Index in the countries of the European Union in 2018–2021
Compiled based on [21], [22], [23], [24].

To address this challenge, these countries need to create an enabling environment that encourages highly skilled workers to stay and contribute to the country's economic development. This includes providing competitive salaries, creating job opportunities, improving working conditions, and offering career growth prospects.

The third group includes Bulgaria, Greece, Romania, Slovakia, Hungary, and Croatia, which belong to countries of the transitive type and have significant problems with the development of human capital and insufficient resources for investing in it. Therefore, characterizing the countries of the European Union according to the parameters of human capital development, it is possible to note the following pattern: in highly developed countries, more attention is paid to the problems of human capital development and the amount of investment is significantly higher than in developing countries.

The pattern observed in the development of human capital in the European Union indicates that highly developed countries pay more attention to the problems of human capital development and

invest more resources in it than developing countries.

However, it is essential to recognize that investing in human capital development is not only a responsibility of highly developed countries but also a requirement for the development of all countries, regardless of their level of economic development.

In conclusion, the development of human capital is critical for the success of organizations and the economic development of countries. The European Union has different levels of human capital development, with highly developed countries investing significantly more resources in it than developing countries. However, it is important to recognize that investing in human capital development is essential for all countries to remain competitive in the global market and ensure sustainable economic growth.

Table 1. Grouping of the countries of the European Union according to the indicators of the Global Competitiveness Index, the Human Development Index, and the Global Innovation Index

Indicator	Number of the cluster		
	I	II	III
Global Competitiveness Index	Austria	Spain	Bulgaria
	Belgium	Italy	Greece
	Denmark	Latvia	Cyprus
	Estonia	Lithuania	Malta
	Ireland	Portugal	Poland
	Luxembourg	Slovenia	Romania
	The Netherlands		Slovakia
	Germany		Hungary
	Finland	The Czech Republic	
	France		Croatia
	Sweden		
Human Development Index	Austria	Greece	Bulgaria
	Belgium	Estonia	Latvia
	Denmark	Spain	Portugal
	Ireland	Italy	Romania
	Luxembourg	Cyprus	Slovakia
	The Netherlands	Lithuania	Hungary
	Germany	Malta	
	Slovenia	Poland	
	Finland	France	Croatia
	Sweden	The Czech Republic	
Global Innovation Index	Denmark	Belgium	Bulgaria
	Germany	The Czech Republic	Greece
	Ireland	Estonia	Croatia
	France	Spain	Latvia
	The Netherlands	Italy	Lithuania
	Finland	Cyprus	Hungary
		Luxembourg	Poland
		Malta	Romania
	Sweden	Austria	
		Portugal	Slovakia
	Slovenia		

Compiled based on: [15], [16], [17], [18], [19], [20], [21], [22], [23], [24].

5 Discussion

Investment in human capital is essential for the long-term success of an enterprise. Developing an effective investment strategy for human capital is critical to achieving a competitive advantage, attracting and retaining talented employees, and fostering a culture of continuous learning and growth.

The strengthening of the destructive impact of global challenges and dangers has led to a decrease in the level of competitiveness of business entities in many countries of the world. Particularly noticeable negative phenomena and processes regarding the development of human capital are observed in the countries belonging to the European Union;

however, they have not completed the transformational restructuring yet. Comparative studies of the main tendencies in the development of human capital make it possible to identify certain patterns that are related to the level of social-economic development of the country. In particular, countries with high indicators of investment in human capital can implement the highest standards of innovative development and combine the introduction of innovations with the progressive development of human capital. Along with this, developing countries put the main emphasis on preserving the existing level of development of human capital, as a result of which they do not focus on improving the quality and efficiency of its use.

Human capital is positioned as a multi-level set of interdependent components, each of which requires investments, in particular: educational, professional, social, and cultural ones. Therefore, its development significantly affects society and the economy, and also determines the main trends of innovative development not only of business entities but also of the entire country.

An effective investment strategy for the development of human capital is critical to the success of any enterprise. By prioritizing the development of critical skills and competencies, leveraging a variety of training and development methods, and incorporating performance management and career development, the enterprise can create a culture of continuous learning and growth and achieve a competitive advantage in the marketplace. In this context, we consider it quite reasonable to propose a further improvement of human capital development tools, one of which is the establishment of a public-private partnership in this direction, which, at the current stage, is the perspective of further scientific investigation.

6 Conclusions

Therefore, the results of studying the main tendencies and problematic issues regarding the formation of an investment strategy for the development of the enterprise's human capital give grounds for asserting that there is no single approach to the formation of such an investment strategy at the level of the European Union. The conducted assessments of the main parameters of this economic category have made it possible to establish its significant dependence on the level of financing in the form of long-term investments, the level of innovative development of the national economy and business entities, and on favorable conditions for conducting business activities. A significant problem of the loss of human capital has been revealed in those countries that are classified as a transitive type of development and have not completed structural restructuring yet (Bulgaria, Greece, Romania, Slovakia, Hungary, and Croatia), in which the values of all analyzed indicators are within crisis limits, and the movement of highly qualified employees takes place in those countries that are highly developed (Austria, Belgium, Denmark, Ireland, Luxembourg, the Netherlands, Germany, Finland, France, and Sweden). As a result of the clustering of the European Union's states according to the indicators of the Global Competitiveness Index, the Human Development Index, and the Global Innovation Index, the

hypothesis that highly developed countries can ensure a higher level of development of the enterprise's human capital while developing countries need advisory assistance, has been proven.

References:

- [1] Lonska, J. & Mietule, I. (2015). The impact of human capital development on the economic and social development of a country: an empirical study. *Environment. Technologies. Resources. Proceedings of the International Scientific and Practical Conference*, 2, 174–180. Available at: DOI: 10.17770/etr2015vol2.268
- [2] Lypych, L., Khilukha, O., Kushnir, M. & Zagoruiko, V. (2019). A Strategic human capital management as part of Business Development. *Economic Journal of Lesya Ukrainka East European National University*, 1 (17), 45–55. Available at: <https://doi.org/10.29038/2411-4014-2019-01-45-55>.
- [3] Timothy, V.L. (2022). The effect of top managers' human capital on SME productivity: the mediating role of innovation. *Heliyon*, 8 (4), 1–8. DOI: 10.1016/j.heliyon.2022.e09330.
- [4] Shamsuzzoha, I. & Tanaka, M. (2020). The Role of human capital on the performance of manufacturing firms in Bangladesh. *Managerial and Decision Economics*, 42 (1), 21–33. Available at: DOI: 10.1002/mde.3210.
- [5] Koo, K.J. (2019). Do not change horses: specialist CEOs enhance innovation. *Technology Analysis & Strategic Management*, 31, 8, 875–887. Available at: DOI: 10.1080/09537325.2019.1566525.
- [6] Liu, J. (2021). Impact of enterprise human capital on technological innovation based on machine learning and SVM algorithm. *Journal of Ambient Intelligence and Humanized Computing*. DOI: <https://doi.org/10.1007/s12652-021-03045-8>.
- [7] Pelinescy, E. (2015). The Impact of Human Capital on Economic Growth. *Procedia Economics and Finance*, 22, 184–190. DOI: [https://doi.org/10.1016/S2212-5671\(15\)00258-0](https://doi.org/10.1016/S2212-5671(15)00258-0)
- [8] Diebolt, C. & Hippe, R. (2018). The long-run impact of human capital on innovation and economic development in the Regions of Europe. *Applied Economics*, 51, 5, p.542–563. DOI: 10.1080/00036846.2018.1495820.
- [9] Paunović, M. (2021). The Impact of Human Capital on Financial Performance of

Entrepreneurial Firms in Serbia. *Management: Journal of Sustainable Business and Management Solutions in Emerging Economies*, 26 (2), 29–46. DOI: <https://doi.org/10.7595/management.fon.2020.0010>.

- [10] Choudhary, S., Memon, N.Z. & Mishra, K. (2020). Examining the Influence of Human Capital on Employees' Innovative Work Behaviour: A Moderated Serial Mediation Model. *South Asian Journal of Human Resources Management*, 7, 2, 189–213. DOI: <https://doi.org/10.1177/2322093720942660>.
- [11] Pasban, M. & Nojedeh, S.H. (2016). A Review of the Role of Human Capital in the Organization. *Procedia – Social and Behavioral Sciences*, 230, 249–253. DOI: <https://doi.org/10.1016/j.sbspro.2016.09.032>.
- [12] Dawud, S.A. (2020). The Impact of Human Capital Development on Economic Growth in Ethiopia. *American Journal of Theoretical and Applied Business*, 64 (4), 47–51. DOI: 10.11648/j.ajtab.20200604.11
- [13] Rahman, M. & Akhter, B. (2021). The Impact of investment in Human Capital on bank performance: evidence from Bangladesh. *Future Business Journal*, 7, 61. DOI: <https://doi.org/10.1186/s43093-021-00105-5>.
- [14] Tereshchenko, D. (2020). Formation of Government Regulation Mechanisms with Human Capital Development. *Investments: practice and experience*, 4, 103–108. DOI: 10.32702/23066814.2020.4.103
- [15] The Global Competitiveness Report 2018. Available at: https://www3.weforum.org/docs/GCR2018/05_FullReport/TheGlobalCompetitivenessReport2018.pdf [Accessed on 17 January 2023].
- [16] The Global Competitiveness Report 2019. Available at: https://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf [Accessed on 17 January 2023].
- [17] The Global Competitiveness Report 2020. Available at: https://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2020.pdf [Accessed on 17 January 2023].
- [18] The Global Competitiveness Report 2021. Available at: <https://www8-international.com/competitiveness-report-2021/pdf/competitiveness-report-2021.pdf> [Accessed on 17 January 2023].
- [19] The Global Talent Competitiveness Index 2020. Available at: https://www.insead.edu/sites/default/files/asset_s/dept/fr/gtci/GTCI-2021-Report.pdf [Accessed on 17 January 2023].
- [20] The Global Talent Competitiveness Index 2021. Available at: https://www.insead.edu/sites/default/files/asset_s/dept/fr/gtci/GTCI-2022-report.pdf [Accessed on 17 January 2023].
- [21] The Global Innovation Report 2018. Available at: <https://tind.wipo.int/record/28174> [Accessed on 17 January 2023].
- [22] The Global Innovation Report 2019. Available at: <https://www.wipo.int/publications/en/details.jsp?id=4434> [Accessed on 17 January 2023].
- [23] The Global Innovation Report 2020. Available at: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2020.pdf [Accessed on 17 January 2023].
- [24] The Global Innovation Report 2021. Available at: https://www.wipo.int/global_innovation_index/en/2021/ [Accessed on 17 January 2023].

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The authors have no conflict of interest to declare that is relevant to the content of this article.

Creative Commons Attribution License 4.0 (Attribution 4.0 International, CC BY 4.0)

This article is published under the terms of the Creative Commons Attribution License 4.0 https://creativecommons.org/licenses/by/4.0/deed.en_US