Methodical approach to the assessment of human capital level of machine-building enterprises

Yevheniia Makazan[1], and *Vita* Los[2,*]

[1]Zaporizhzhia National University, Faculty of Managements, Zaporizhzhia, 69600, Ukraine
[2]Zaporizhzhia National University, Faculty of Economics, Zaporizhzhia, 69600, Ukraine

Abstract. Human capital is a key factor in the success of any enterprise. Since human capital, like other types of capital, is prone to exposure to various types of risk and an important task of any enterprise is to assess the level of human capital. This paper proposes the author's approach to the formation of the structural components of human capital. Its structure included three sets of indicators that characterize educational, intellectual and physical capital. Also, a methodological approach is proposed to evaluate the human capital level of machine-building enterprises, which consists of three interrelated stages. The methodological approach is based on a point evaluation of the indicators included in the human capital structure based on the questionnaire (polling) of the personnel of the analyzed machine-building enterprises. The assessment of the level of human capital was carried out separately for two groups of workers. It is established that the total value of the integral index of human capital corresponds to the average level for all examined enterprises and ranges from 0,463 to 0,585. It has been found that the personnel at the machine-building enterprises have a great potential for development and a high propensity for change. The advantage of human capital assessment on the basis of its structural components is the ability to determine the optimal need for human resources and forecast the cost of supporting and developing human capital.

1 Introduction

The great competition that is observed in the domestic and foreign markets makes the managers of enterprises think about creating a tool that will increase the competitive advantage of the enterprise. One such tool is a human capital. In the papers [1, 2], it is stated that the assets of the enterprise based on knowledge are reflected in patents, brands, reputation of the enterprise and in the available human resources.

To date, a human capital is a key success factor for any enterprise and the most significant asset focused on an intellectual capital and a technology. The enterprises that effectively utilize the skills and the knowledge of their staff, are in the lead. Since the human capital, like other types of capital, is exposed to various types of risk, for example, the risk of expediency of investing in human resources, the risk of payback, an important task of any enterprise is the assessment of the human capital [3].

Many papers of foreign and domestic scientists are devoted to the issue of human capital assessment. The authors of [4] describe human capital in the form of skill databases based on a systematic approach. Also, R. Germon, P. Laclemence and B. Birregah [5] propose the matrix approach that enable to diagnose key threats to the development of the human capital of an enterprise. In the papers [6] analyzed the indicators of human capital assessment and defined the main criteria for evaluation and their impact on human capital. It also outlines the internal structure of human capital, which includes the funds of health, migration, motivation, intellectual capital and other funds. O. E. Kuzmin and A. Y. Shakhno [7, 8] used indicators to determine the index of human development and capital in assessing the country human capital. That is, macroeconomic indicators were used in the assessment. The study [9-11] proposed the human capital structure of the country, which consists of four groups, namely: economic indicators, demographics, education and science indicators. The author attributes to each of the proposed groups a system of indicators that characterize it. The scientist also noted that in the formed structure it is necessary to add indicators that would reflect the current state of qualitative components of human capital. Therefore, it is reasonable to develop existing methods and develop new modern approaches to human capital assessment. Human capital assessment on the basis of its structural components is extremely important, as it will determine the optimal need for human resources, predict the costs of maintaining and developing human capital in the short, medium and long term.

The level of development of the machine-building industry is characterized by the defense capability and scientific and technical state of development of the national economy of the country. Products in this field have a high level of science linkage and require a high level of knowledge, which in turn requires research into the issues of formation and assessment of human capital.

* Corresponding author: vitalos.2704@gmail.com

Analyzing scientific paper on the study and structure of human capital, it was found that each scientist forms his own vision of this category. But the structural components of human capital include both production and professional characteristics of staff. However, in our opinion, that individual (personal) traits of a person that determine their ability to self-development are very important. Focusing on personal traits, we have developed the human capital structure of machine-building enterprises (Figure 1), which takes into account the main components that most scientists adhere to, namely ability, skills and health.

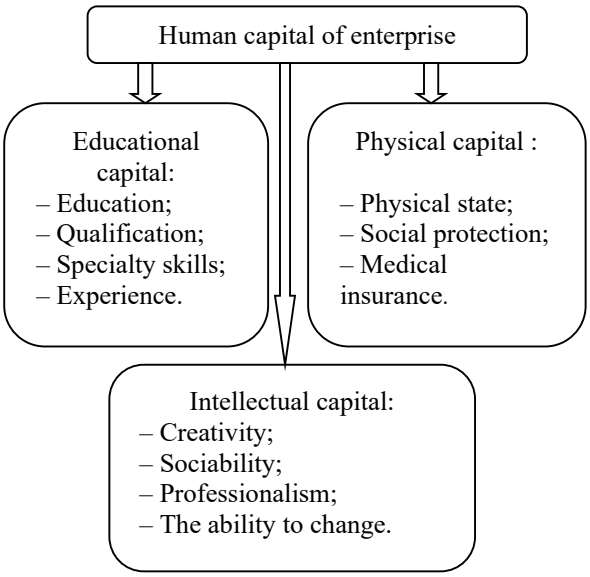

Fig. 1. Structural elements of human capital of the enterprise

Educational capital is formed on the basis of acquired knowledge, competences, education, qualifications. Experience is also an important component, reflecting the skills of a person as a result of a practical activity.

Intellectual capital characterizes the set of human mental abilities, forms the ability to absorb, analyze and process information, the propensity for creativity and the ability to generate innovative ideas.

Physical capital or physical health is one of the main components of human capital, because a physically healthy person will only develop professionally and generate new suggestions and ideas. The structural element "physical condition" analyzes the frequency of hospitalization at an enterprise, which characterizes the state of health of staff; "social protection" means the presence of a social package and social infrastructure in an enterprise; "health insurance" means the presence of an insurance pole. Also important is the psychological and moral health of the person. When the staff is positively tuned, the team creates comfortable conditions and thus forms an appropriate level of corporate culture. A sufficient level of corporate culture creates the conditions that facilitate the realization of new ideas and professional ambitions of the staff, which in turn contributes to the development of the enterprise as a whole.

2 Methodical approach to human capital assessment of the enterprise

On the basis of the formed human capital structure, the authors proposed a methodological approach to the human capital level of machine-building enterprises (Figure 2).

The proposed approach involves several major steps. The first stage is the examination, that is, the point evaluation of the level of educational, intellectual and physical capital on the basis of the questionnaire (polling) of employees. The second stage is the analysis of the information received, it involves establishing a link between the structural elements of each component of human capital and identifying the degree of consistency of expert assessments. The last third stage is an integrated assessment of the level of human capital. At this stage, the normalization of the input data, determination of the weight coefficients of the components of human capital and its integral evaluation.

On the basis of the proposed methodological approach, the human capital level of enterprises of the machine-building industry of Ukraine was evaluated. The polled enterprises were grouped into three groups: large, medium and small. A group of experts was hired to make polling and interviews with machine-building enterprises personnel. According to the results of the interviews, the experts rated the personnel on each structural element using a score scale from 1 to 7. The higher the score, the higher the level of the studied indicator [12].

Interviews were conducted separately for two groups of employees, namely: engineering and production staff. Expert assessments for each criterion were averaged for both the selected staff groups and for each of the examined enterprises.

According to the results of research of large machine-building enterprises, it is established that engineering and technical workers have a high level of education, creativity, communication skills and work experience. Average level of social security and health insurance. The production staff of JSC "Motor Sich" has the highest level of education, communication skills, specialty skills, professionalism and social protection of the companies under consideration. It should be also noted that the production staff of JSC "Motor Sich" and PJSC "ZAZ" are the most prone to changes and have a good level of physical condition.

Of all the (large) enterprises surveyed, PJSC "ZAZ" has the lowest ratings, which is not surprising since the company is in crisis. The volume of production and sale of products is very low, so in 2017 about 1% of the production capacity of the enterprise was involved in production.

Accordingly, expert assessments of the structural components of human capital in this enterprise are low.

According to the results of the examination of medium-sized enterprises, it was found that the highest level of education, among engineering and technical workers, was recorded at JSC "Zaporizhkran" which corresponds to a good level. Employees of JSC "Zaporizhkran" and LLC "ZAZOSNASTKA" have an

average qualification level. The employees of all the examined enterprises have a good level of skills, professionalism and work experience. Also, employees are prone and innovative and have a good level of physical condition. Employees of JSC "Zaporizhkran" were the most sociable and professional employees. The production staff of all the examined enterprises have a high level of education, high specialty skills and sufficient experience. At the following enterprises such as State Enterprise "ZDARZ" MiGremont "and LLC "ZAZOSNASTKA" the employees are prone to changes and have a good level of physical condition.

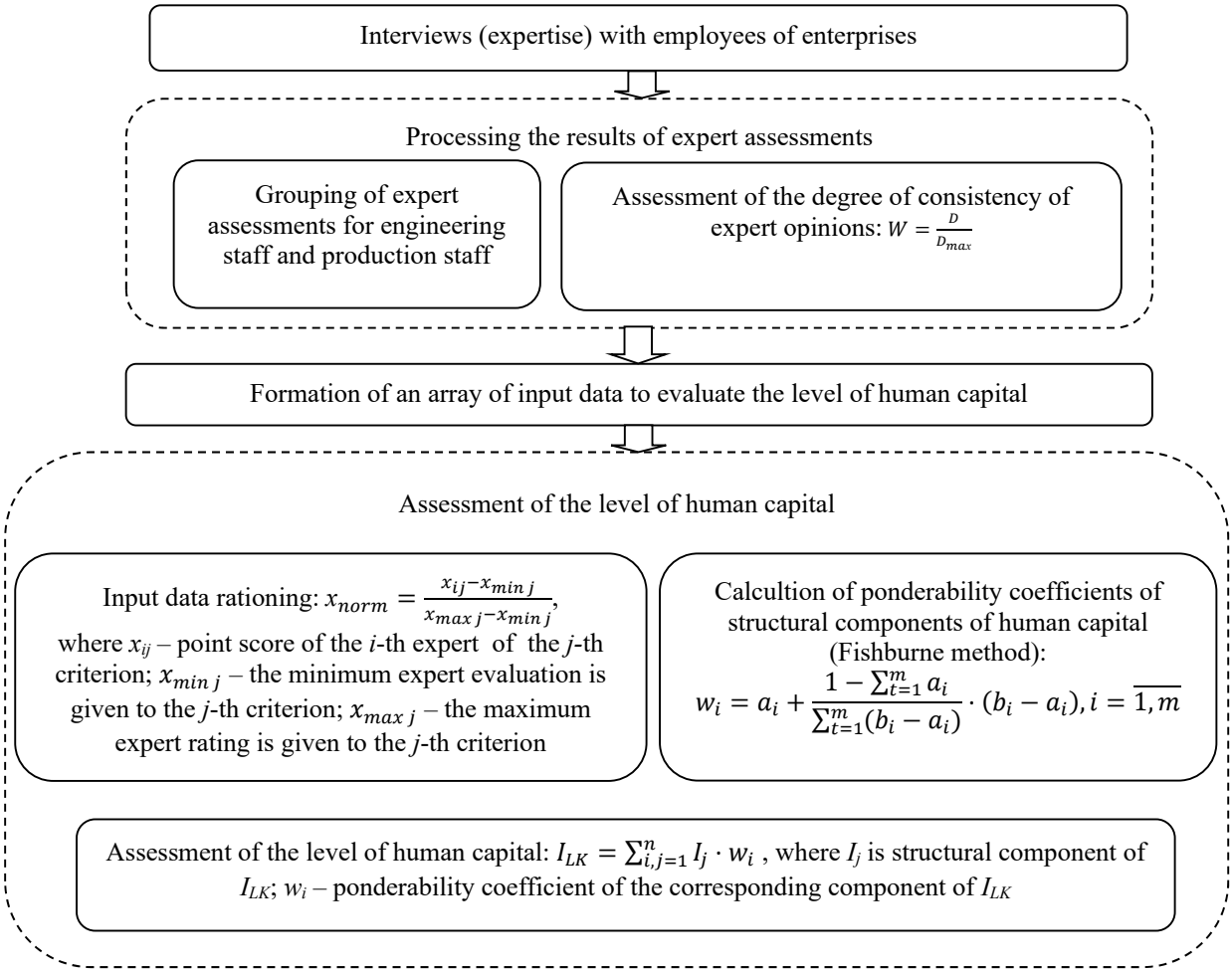

Fig. 2. Methodical approach to the human capital level of machine-building enterprises.

As a result of the expert evaluation of small enterprises, a high level of work experience, education and skills in the specialty has all engineering and technical staff. Analyzing the structural components of intellectual capital, it is clear that, according to the experts, the employees of these enterprises are characterized by a high level of creativity and communication skills. Engineering workers are prone to changes both in the professional sense and in the direction of forming the corporate culture. The physical condition is assessed to be good and social protection is therefore unsatisfactory and requires appropriate measures to be taken to increase the indicator. The production staff of small machine-building enterprises are characterized by a high level of work experience, professional skills, specialty skills and a tendency to change. Summing up the expert evaluation, we can conclude that the employees of these enterprises have high rates of human and intellectual capital, and the physical is slightly lower. Therefore, management should pay attention to this fact and develop a plan of measures to improve social protection and health insurance.

After grouping and averaging expert assessments, we will establish the link between the structural elements of each component of human capital. To do this, we calculate a nonparametric multiple correlation coefficient V , which is calculated by the formula [15]:

$$V = \sqrt{\frac{S}{(1/12)m^2 \cdot (d^3 - d)}}, \quad (1)$$

where d is the number of experts, m is the number of criteria,

S is the sum of squares of classes differences (deviations from the mean) and is determined as follows: $S = \sum |r_i - a| \cdot 2$, where a is the arithmetic mean of the sum of the classes.

Next, we determine the degree of concordance of expert opinions using the dispersion coefficient of concordance W (see Fig. 2). The results of the calculation of the correlation coefficients are given in Table 1.

The values of the obtained correlation coefficients are in the range from $0 \leq V, W \leq 1$. Therefore, we can conclude

that there is a significant relationship between the structural elements of human capital, since their values are in the range of $0.64 \le V \le 0.75$ for engineering staff and from $0.65 \le V \le 0.88$ for production personnel.

Based on the results of the calculations (Table 1), we can also conclude that the experts' estimates are sufficiently consistent, since the value of the coefficient of concordance is more than 0.5. In the study of production personnel, the consistency of experts is very high, since $W > 0.7$.

Table 1. Calculation of correlation coefficients.

Structural component of human capital	Engineering technicians (ET)		Production staff (PS)	
	V	*W*	*V*	*W*
Large enterprises				
Educational capital	0.641	0.788	0.734	0.712
Intellectual capital	0.755	0.678	0.882	0.790
Physical capital	0.647	0.687	0.657	0.793
Medium-sized enterprises				
Educational capital	0.641	0.788	0.734	0.712
Intellectual capital	0.715	0.687	0.882	0.790
Physical capital	0.647	0.688	0.657	0.793
Small enterprises				
Educational capital	0.693	0.759	0.832	0.599
Intellectual capital	0.585	0.879	0.627	0.634
Physical capital	0.620	0.727	0.609	0.873

According to Fig. 2, the next step is the normalization of the initial data and the determination of weighting factors. The indexation of indicators was carried out using the formula shown in Fig. 2. The weighting factor of each structural element will be determined using the Fishburne`s method [15]. This method is used when possible intervals of values of weighting factor are known. The expert team, during the examination, established possible limits for each of the indicators and structural components of human capital. The results of the calculation of the weighting factor for the indices of each structural component are given in Table 2.

Table 2. Ponderability coefficients of human capital components.

Indicators	Legend	Weighting factors, w_i
Structural elements of educational capital		
Education	x_1	0.215
Qualification	x_2	0.270
Specialty skills	x_3	0.277
Experience	x_4	0.238
		$\sum_{t=1}^{m} w_i = 1$
Structural elements of intellectual capital		
Creativity	x_5	0.210
Sociability	x_6	0.191
Professionalism	x_7	0.283
The ability to change	x_8	0.316
		$\sum_{t=1}^{m} w_i = 1$
Structural elements of physical capital		
Physical state	x_9	0.416
Social protection	x_{10}	0.296
Medical insurance	x_{11}	0.288
		$\sum_{t=1}^{m} w_i = 1$

Therefore, based on the calculations (Table 1) we can conclude that the most important components of educational capital are the skills in the specialty and qualification of employees. For the group of intellectual capital indicators, the most important is the ability to change, that is, the ability to develop and learn. As regards the weight of structural elements of physical capital, it is evident that the most important is the physical condition of employees. Of course, this component, in our opinion, is extremely important, because only a physically healthy worker will work with the maximum possible productivity and will strive for professional development.

The results of the averaging of the expert scoring with regard to the weighting factor for each group of enterprises are shown in Fig. 3–5.

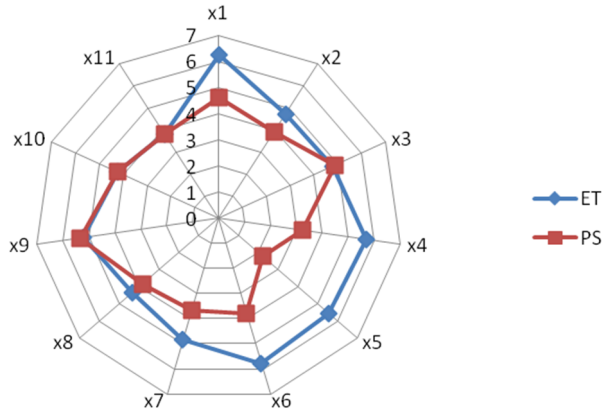

Fig. 3. Average point expert evaluation of the human capital components of large machine-building enterprises for 2018 (in conventional units).

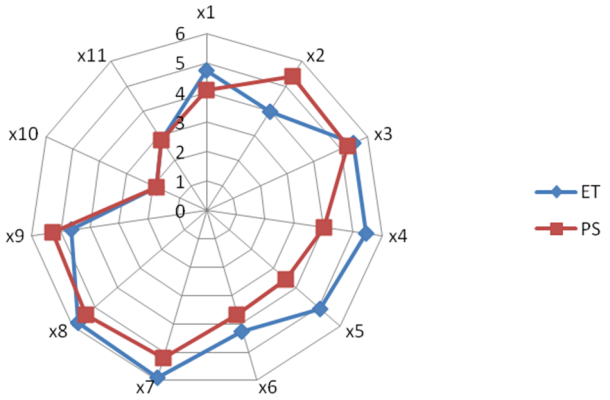

Fig. 4. Average point expert assessment of human capital components of medium-sized engineering enterprises for 2018 (in conventional units).

At the Fig. 3 we can see that engineering workers have 1.3 times higher education level, they are more creative and communicative with respect to production staff. This is due to the fact that the technical staff are more ambitious and prone to career advancement. It should be noted that production staff have a higher level of specialty skills (1.01 times) and have a better physical condition. The summed average point expert evaluation of the studied medium-sized machine-building enterprises (Fig. 4) indicates the high level of skills in the specialty, experience, creativity, professionalism and ability to change. Engineering workers are 1.43 times more creative and have more

experience (1.35 times) than manufacturing staff. Employees have good close to high level physical condition. The physical condition of production personnel is 1.13 times higher than at the engineering technicians. It is also worth noting that production personnel are more highly qualified (1.36 times) than engineering workers.

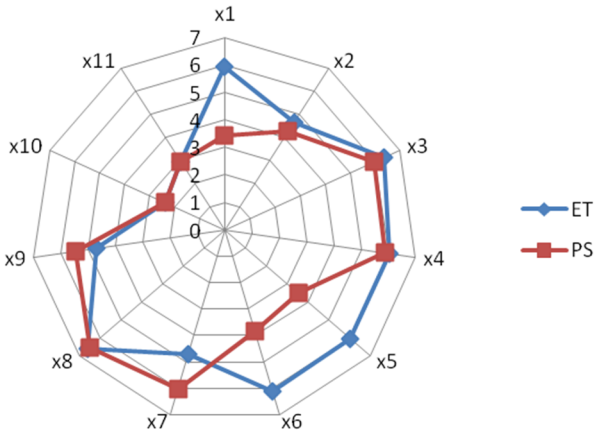

Fig. 5. The average point expert assessment of the human capital components of small machine-building enterprises for 2018 (in conventional units).

The weighted average point expert assessment of small enterprises indicates that the ability to change is paramount. This, in turn, indicates that the staff is ready for innovation, development and implementation of innovative ideas. Also, the Fig. 5 shows that almost all structural components of engineering and technical workers have higher grades than production personnel. The production personnel have higher average scores only on two indicators "professionalism" and "physical condition".

Weighting factors of the structural components of human capital were also determined using the Fishburne`s method. So weighting factors of educational capital is 0.331, of intellectual capital is 0.399, of physical capital is 0.270. Therefore, the most significant component of human capital is intellectual capital. Having determined weighting factors, we proceed to the next stage, namely, to estimate the level of human capital of engineering enterprises.

For large enterprises, the level of human capital is:

$$I^{V}_{LK(ITP)} = 0.619 \cdot 0.331 + 0.553 \cdot 0.399 + \\ +0.591 \cdot 0.270 = 0.585, \\ I^{V}_{LK(BIT)} = 0.595 \cdot 0.331 + 0.489 \cdot 0.399 + \\ +0.586 \cdot 0.270 = 0.550. \quad (2)$$

To explain the results of the level of the integral index of human capital and its structural components, we use the Harrington scale of desirability [15]. Therefore, the obtained level of integral index of human capital of large machine-building enterprises corresponds to a satisfactory level. But the level of human capital of engineering and technical workers is higher by 6.3% than the production personnel. The educational capital of engineering staff is 0.62 and indicates that this component is at a good level. All other values of the structural components of human capital range from 0.49 to 0.59, which corresponds to a satisfactory level.

For medium-sized enterprises, the level of human capital is:

$$I^{S}_{LK(ITP)} = 0.534 \cdot 0.331 + 0.412 \cdot 0.399 + \\ +0.470 \cdot 0.270 = 0.468, \\ I^{S}_{LK(BIT)} = 0.486 \cdot 0.331 + 0.475 \cdot 0.399 + \\ +0.418 \cdot 0.270 = 0.463. \quad (3)$$

The obtained values of the structural components of human capital according to Harrington's scale of desirability correspond to a satisfactory level. Educational capital of engineering and technical workers is 9.8% higher than production personnel. But the level of intellectual capital is higher for production personnel than for engineering and technical by 15.4%. As for physical capital, it is higher by 12.5% for engineering and technical workers. The overall value of the integral index of human capital of medium-sized machine-building enterprises corresponds to a satisfactory level, the level of human capital is higher by 1% for engineering and technical workers.

For small enterprises, the human capital level is:

$$I^{M}_{LK(ITP)} = 0.495 \cdot 0.331 + 0.561 \cdot 0.399 + \\ +0.488 \cdot 0.270 = 0.519, \\ I^{M}_{LK(BIT)} = 0.484 \cdot 0.331 + 0.515 \cdot 0.399 + \\ +0.455 \cdot 0.270 = 0.489. \quad (4)$$

The integral index of human capital of small machine-building enterprises corresponds to a satisfactory level. The human capital of engineering and technical personnel is 6.2% higher than the similar figure for production personnel. Educational, intellectual and physical capital of engineering and technical staff is also higher than that of production staff by 2.1%, 8.8% and 7.1% respectively. Therefore, we have determined the level of human capital of machine-building enterprises in terms of large, medium and small. It is established that the generalized value of the integral index of human capital corresponds to the average level for all investigated enterprises (Fig. 6).

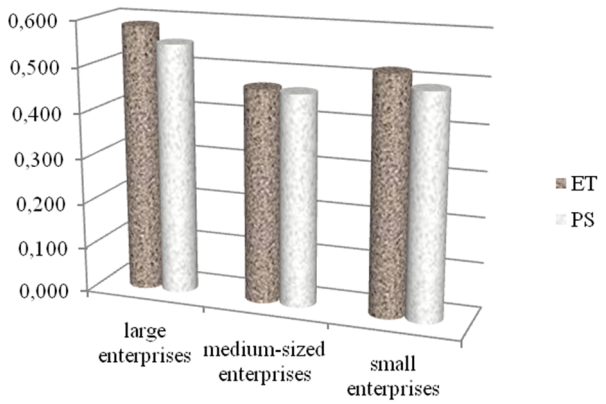

Fig. 6. The human capital level of machine-building enterprises of Zaporizhzhia region for 2018 (in conventional units).

The Fig. 6 shows that the lowest level of human capital is recorded in medium-sized enterprises. At large machine-building enterprises, the level of human capital of engineering and technical workers is higher by 25% compared to medium-sized enterprises. And in small enterprises the level of human capital is higher by 10.9% compared to the medium-sized enterprises. The level of human capital of production personnel in large enterprises is also higher: by 18.8% relative to medium-sized enterprises and by 12.6% relatively small enterprises. Large machine-building enterprises have the highest level of human capital and it makes in average of ILK = 0,568, which is 22% more than medium-sized enterprises and 12.7% more than small enterprises

3 Conclusions

Of great importance for the development of any industry is the staffing of the production process. Analyzing the general dynamics of the number of employees, there is an outflow of personnel potential both in industry as a whole and in mechanical engineering. This process is influenced by many different factors, and one of the main ones is the lack of material incentives for workers, which remains at a very low level. Therefore, to improve the situation with personnel, attention should be paid to the corporate culture of the enterprises of the machine-building complex, attracting highly qualified personnel by mobilizing financial resources to motivate and increase labor productivity in the future.

Improvement of the structure of human capital and its components, reflecting the basic individual (personality) features of person, which determine his ability to self-development is the scientific innovation of this paper. Suggested approach enables us to identify the strong points of the enterprise and the optimal need for human resources, to forecast the costs of supporting and developing human capital in the short, medium and long term. The proposed methodological approach to human capital assessment consists of three interrelated steps. The methodological approach is based on the expert evaluation of human capital components, namely the level of educational, intellectual and physical capital based on the questionnaire (polling) of employees. The approbation of the proposed approach was implemented to evaluate the human capital level of machine-building enterprises, which was grouped into three groups: large, medium and small.

The survey was conducted separately for two groups of workers, namely: engineering and technical workers, and industrial personnel. In accordance with the results of the calculations, it was found that the human capital of the researched enterprises, according to the Harrington scale, corresponds to a satisfactory level. Large enterprises have the highest level of human capital, and medium enterprises have the least. At large machine-building enterprises, the level of human capital of civil engineering workers is 25% higher in comparison with medium-sized enterprises. And in small enterprises, the level of human capital is higher by 10,9% compared with medium-sized enterprises. The level of human capital of industrial personnel in large enterprises is also higher: 18,8% relative to medium and 12,6% relative to small enterprises.

It should also be noted that the staff at the examined enterprises has a great potential for development and a high propensity for changes. Therefore, the research that is aimed at developing human capital based on the formation of a quality corporate culture is important. This direction of development will help improve the psychological climate in the team and increase the level of human capital.

The practical value of the paper is using the results of the research, which allow analyzing the level of human capital in the machine-building industry, determining the main aspects of the enterprise and formulating competitive advantages on their basis. Also, the results of the research provide an opportunity to justify the development strategy of the enterprise, taking into account elements of corporate culture.

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