Cluster Analysis Of Motivational Management Of Personnel Support of IT Companies

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Abstract

The article examines the motivational component of business models of IT companies in Ukraine. The research was conducted by cluster analysis of statistical data hosted by companies on the information platforms DOU, Clutch, and Linkedin. The following indices of satisfaction with employees of enterprises were studied: compensation, working conditions, career, project, loyalty, as well as the general consolidated index. Also, to identify patterns, a cluster analysis of these indicators with data on the scale of companies: the total number of employees and the percentage of employees registered in Ukraine. A high level of motivational management in companies with a high percentage of Ukrainian employees was revealed. The result confirms the results of previous studies by the authors that the factors restraining the potential growth of the IT market in Ukraine lie in the field of education.

Keywords [1]

Cluster analysis, motivation, enterprise management, information technology

1. Introduction

The presence of a large number of highly qualified specialists in engineering specialties with high-quality fundamental training has ensured Ukraine's position as one of the main European countries supplying human capital, including intellectual, to countries with developed economies. In 2021, the IT industry received a record growth of + 37.0%, confidently reaching 1st place in terms of exports of services. The growth of the IT industry is projected in the future, but staff shortages are significantly hampering this development. The average number of responses to an open vacancy is constantly declining. In December 2019, one vacancy received 8.12 resumes, in December 2020 - 6.16, in December 2021 - 4.21. The only exceptions are responses to vacancies opened after the start of a full-scale Russian invasion of Ukraine, according to analysts jobs.dou.ua [1] the number of responses to vacancies in April 2022 rose sharply to 12.6, however, this is a temporary phenomenon. The results of the survey of the target focus group on the LinkedIn platform, in which recruiters, Talent Acquisition, and HR managers of Ukrainian IT companies took part, showed that the main reasons hindering job vacancies are: "high requirements / complex project tasks (61% and 30% of respondents, respectively) "[2]. The reasons for the lack of skilled workers in the field of information technology, in general, are discussed on numerous platforms. Thus, the Center for Economic Recovery in cooperation with the Ministry of Digital Transformation of Ukraine and the Ministry of Education and Science, as well as with the involvement of key stakeholders, namely IT clusters, leading IT companies (Cisco, Eleks, Epam, Genesis, GlobalLogic, Luxoft, N-IX, Parimatch, SoftServe, Telesens), business and IT associations (ACC, EASE, EBA, ITEC, IT Ukraine, Union of Ukrainian Entrepreneurs, SoftServe Ukraine, UAITP, UVCA), public and international organizations (National Investment Council of Ukraine, USAID, BRDO, YEP, dComFra, STEM is Fem, STEM Girls, Digital Ukraine), as well as several higher education institutions, in July 2021 held a discussion with the

publication of materials entitled "Express analysis of the current state of IT education in Ukraine". In a conclusion, it was stated the fact that "The pace of training of IT professionals does not meet market demand and hinders the growth of the IT sector [3].

However, the global problem cannot be solved quickly, in particular, due to the large-scale invasion of the Russian aggressor in Ukraine, so the management of IT companies must satisfy their staffing requirements, based on internal reserves of available human capital.

The economic feasibility of using such a form of employment as a self-employed entrepreneur allows employers to avoid legal obligations to employees. In its materials, the International Labor Organization testifies to the growth in the global dimension of temporary employment, part-time employment, self-employment (freelance), and the spread of "disguised" forms of labor relations [4]. Researchers Mark Mortensen and Heidi K. Gardner analyzed the work of 500 managers in multinational companies and found that 81% of specialists working in teams also work part-time. Additional explorations have given an even higher figure - for example, in knowledge-intensive industries, this figure is 95% [5].

The dangers for workers and the immediate unilateral benefits for employers of informal employment are quite ambiguous. The desire and economic need to hire the best professionals in the face of growing competition balance these risks, giving the employee freedom of choice. Strategic talent management is discussed, in particular in Bernhard Rosenberger's book "Modern human resource management" [6]. This book provides a sound description of the five main areas of activity in modern personnel management: strategy, organization, leadership, personnel development, and personnel management. Additions to the 3rd edition of this book are, among others, the articles "Feedback - a must for agile work" and "Recruitment - opportunities, and opportunities in times of shortage of skilled workers."

Employees of IT enterprises become pioneers among employees of other industries, for whom the work is personified with a certain occupation, with the business as a whole, and not with attachment to a particular workplace or organization, regulated working hours, and organizational hierarchy. That is why motivational aspects in building business models of IT enterprises play an increasingly important role.

The research is devoted to proving or refuting the hypothesis of low-quality motivational management of IT enterprises in Ukraine, as the reason for insufficient staffing in the industry.

2. Related Works

The importance of motivation management is explored in the article Jain, A., Gupta, B., & Bindal, M. "A study of employee motivation in organization" [7]. In particular, the article substantiates that "Employee Motivation is the key factor to help up the capacity of an association. In the globalization stage, each organization needs to continue itself in a furiously focused market. Representatives are the fundamental elements to show the business objectives into the real world. Subsequently, in the present world each association attempts to deal with its human asset office to keep its representatives inspired. In that specific circumstance, some of the administration speculations have been rehearsing by them. Business work or their presentation in the market can be assessed by surveying the degree of inspiration of representatives. Inspiration can assume a lead job to get the expert achievement in each budgetary year in a less exertion way. While trying to find what inspires representatives, representative inspiration inquire about papers report that what spurs laborers today is fundamentally connected to the qualities and objectives of the person".

Birendra Nath Singh у статті «Theory A, Theory B and Theory C of managing people at work» notes that Managing people and productivity are prime concerns of modern business organizations [8].

The influence of employee motivation and its influence on job satisfaction is studied in the example of Bank-Sohar International-Muscat Oman [9].

Bogatska N. [10] conducts research on motivation as the main factor in increasing work efficiency. The author defines motivation as a process of stimulating staff to improve the efficiency of activities aimed at achieving the strategic goals of the enterprise.

The research of labor motivation, its efficiency in the management of labor resources, as well as the assessment of the motivation of the production staff of the enterprise are devoted to the research of Klimenko I. [11].

In publications written by Zastavniuk L.I., Lypovetska T.R. [12], Klimchuk AO, Mikhailov [13] problems of personnel motivation system in the modern enterprise are considered.

Motivation, as one of the conceptual foundations of management in the information economy, is studied by T. Lepeyko, O. Pushkar, and O. Mironova [14].

However, the authors did not find any materials that would study the relationship between the types of employee motivation and the scale of the company, as well as other indicators of the effectiveness of management of enterprises in the field of information technology.

3. Methods and Materials

Given the crucial role of professional qualities of team members and the growing competition of IT companies, employee motivation is becoming a crucial factor in forming, maintaining, and building a team. As you know, a very important component of the company's business model is the offer of certain values to the client, which this company can provide with its work. Therefore, the professional and human qualities involved in the team of specialists come to the fore and become an integral part of the company's description in the IT market.

The authors analyzed the results of an anonymous and voluntary survey of employees of IT enterprises in Ukraine on the platform jobs.dou.ua [15] in order to obtain information on satisfaction indicators on five indicators: "compensation", "working conditions", "career", "project ","loyalty". Respondents rated their satisfaction with a certain category on a scale of 0 - 100%, where 0% corresponds to complete dissatisfaction and 100% - to absolute satisfaction. The obtained individual results are averaged by companies and clustered. A total of 236 IT companies in Ukraine were studied. The optimal number of clusters is 5, obtained by elbow and silhouette methods. Also, in order to analyze the relationships, statistical information on the scale of each company was collected based on company profiles on online platforms careers.linkedin.com, clutch.co, and jobs.dou.ua.

3.1. About clustering method

Clustering is the division of a set of objects into subsets (clusters) that do not intersect, to combine into separate groups the most similar to each other. Objects that differ significantly due to clustering will belong to different clusters.

The problem of clustering can be formulated as follows: a given set of n vectors, each of which has dimension d, must be divided into subsets (according to a given optimization criterion). Usually, the optimization criterion is to minimize distortion.

It is proposed to use the method of k-means [16], which minimizes distortion by dividing the data between subsets (domains) that do not intersect and are represented by a centroid element and the "distance" of other clusters elements from the centroid. Its main advantages are simplicity and guaranteed convergence over several iterations.

Clustering by the k-means method distributes the input set of n vectors by k clusters $S_i (i = 1, 2, \ldots k)$, with each of which the centroid $c_j = (c_{1j}, c_{2j}, \ldots, c_{dj})$. Denote by $S = \{x\}$ the power set n of the input vectors $x = (x_1, x_2, \ldots, x_d)$. Let $D(x, c)$ – be the distance between the vector x and the centroid c. This article uses the weighted Euclidean distance:

$$D^2(x, c) = \sum_{i=1}^{d} \quad .$$

Denote the set of centroids obtained by iterating t, $Sc^{jt} = \{c^{jt}\}$. The algorithm for clustering *k-means* in its usual version is described as follows:

1. Let set t = 0 and set the initial location of the centroids Sc^{j0}.
2. For a given set of centroids Sc^{jt} perform the steps specified in paragraphs 2.1 and 2.2, and obtain an improved set of centroids Sc^{jt+1}:

    2.1. Let's find a partition S^j, that distributes the original set of n input vectors over k clusters $S^j (j = 1, 2, \ldots k)$ and satisfies the condition

$$S^j = \{x : D(x, c^r) \leq D(x, c^s) r \neq s\}$$

2.2. Calculate the centroid c^{jt} for each cluster $S^j (j = 1, 2, \ldots k)$, to obtain a new set of centroids Sc^{jt+1}:

$$c_s^j = \frac{1}{m_j} \sum_{i=1}^{m_j} x_{si}^j, s = 1, \ldots d,$$

where m_j – the number of vectors belonging to the cluster S^j.

3. Calculate the total distortion $E^2 = \sum_{x \in S} D^2(x, c)$ for Sc^t. If it differs from that obtained in the previous iteration by a sufficiently small value, stop the process. Otherwise, assign $t \rightarrow t + 1$ and return to step 2.

The clustering error and the number of iterations depend on the initial choice of centroids, so it is common practice to run k-means several times with different initial centroid candidates.

In this paper, the choice of the number of clusters was based on a comparison of the results obtained by the elbow method and the assessment of the silhouette.

The basic idea of determining the number of clusters by the elbow method is to select such a number of clusters that the total variation between clusters, ie the total variation within the cluster, was minimized. There are several algorithms for the calculation of variation, this paper uses an algorithm that defines the total variation within the cluster as the sum of the quadratic Euclidean distances between the elements and the corresponding centroid:

$$W(C_k) = \sum_{x_j \in C_k} (x_j - \mu_k)^2.$$

Since there is a high probability that the input data will not be clearly distributed between clusters, and as a result, the separation obtained by using the elbow method will not correspond to the highest score of breaking quality [15], it is proposed to combine this elbow method with the simplified silhouette method.
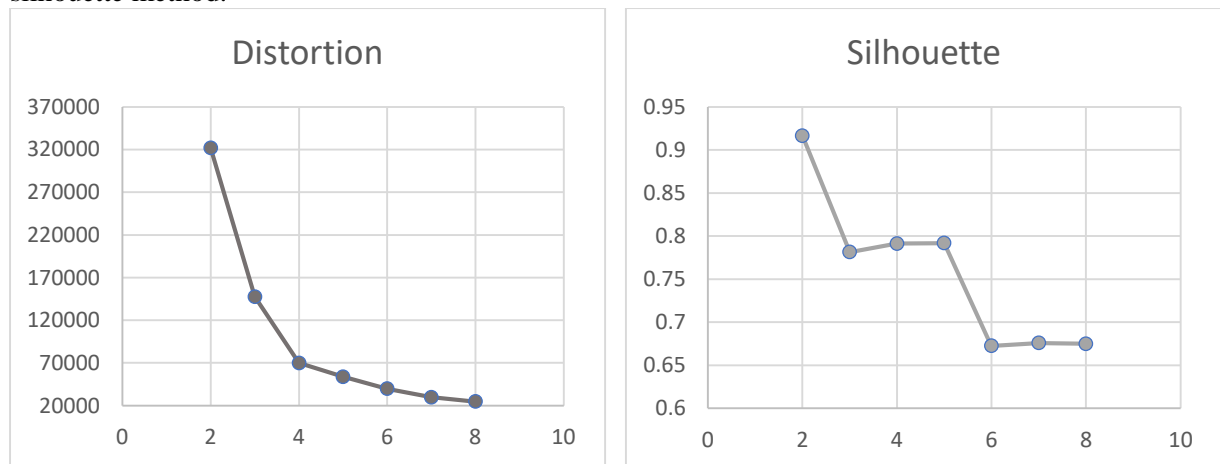

Figure 1. The results of the elbow method and the method of estimating the silhouette of finding the optimal number of clusters.

Based on the obtained graphic images, it was concluded that the optimal result is obtained in the case of three, four, or five clusters (Figure 1). However, since the results obtained by using the elbow method do not always correspond to the highest assessment of the quality of the break, it is proposed to combine this method of the elbow with the method of assessing the silhouette. The division into 5 clusters is considered optimal.

4. Experiment and results. Кластеризація зібраних даних

Due to the lack of some indicators on all IT companies registered in Ukraine, the authors focused their research on 236 brand companies for which they managed to collect complete information on the mentioned indicators on the mentioned platforms in personal profile files.
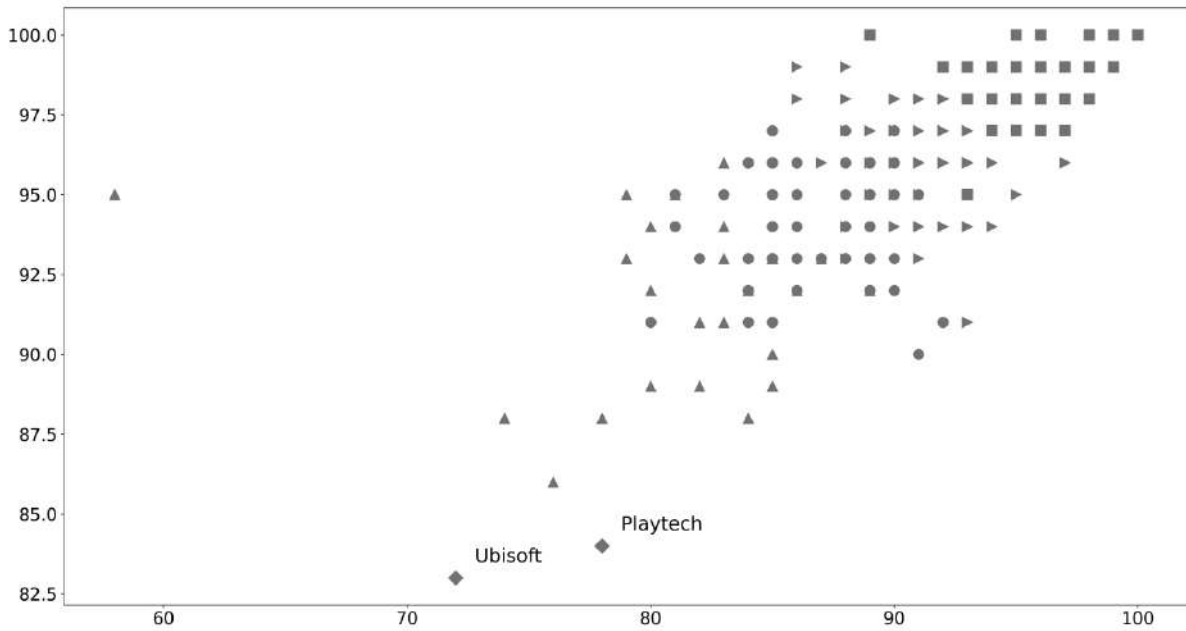
Figure 2. Clustering by categories of employee satisfaction indices. OX axis - "Compensation", OY axis - "Working conditions". (■ - 0 cluster; ▶-1-cluster; ● - 2-cluster; ▲ - 3-cluster; ◆ -4-cluster.

Cluster «0» were 55 companies with the highest performance in all indices. The centroid of the cluster received the values: "compensation" - 96%, "working conditions" - 98.5%, "career" - 97.1%, "project" - 97.6%, "loyalty" - 98.7. This cluster includes three companies with 100% satisfaction in all categories, namely Crunch, Codemotion, and Ubisoft. In four categories (except "compensation") with 100% satisfaction recorded the company Ringostat In the category of "compensation", in addition to the above, with 100% satisfaction recorded 8 more companies with 100% satisfaction in the category of "working conditions", in the category of "career" - bvblogic, in the category of "project" - bvblogic, JatApp, MWDN, ProArea, Vilmate, and 13 companies in the category of "loyalty".

Cluster «1» amounted to 94 companies with higher than average satisfaction indices. The centroid of the cluster received the values: "compensation" - 91.3%, "working conditions" - 96.4%, "career" - 92.4%, "project" - 94.2%, "loyalty" - 96, 3%.

Cluster «2» formed 60 companies with average employee satisfaction indices. The centroid of the cluster was: "compensation" - 96.6%, "working conditions" - 94%, "career" - 88.2%, "project" - 90.4%, "loyalty" - 92.8% .

Cluster «3» amounted to 25 companies with lower than average employee satisfaction indices. The centroid of the cluster was: "compensation" - 81.2%, "working conditions" - 91.6%, "career" - 83%, "project" - 86.6%, "loyalty" - 88.8%.

Cluster «4» formed the two companies Playtech and Ubisoft with the lowest rates. The centroid of the cluster received the values: "compensation" - 75%, "working conditions" - 83.5%, "career" - 66%, "project" - 73.5%, "loyalty" - 74.5%.

The results of joint clustering by satisfaction indices and scale of enterprises shown in Figure 3 are interesting.
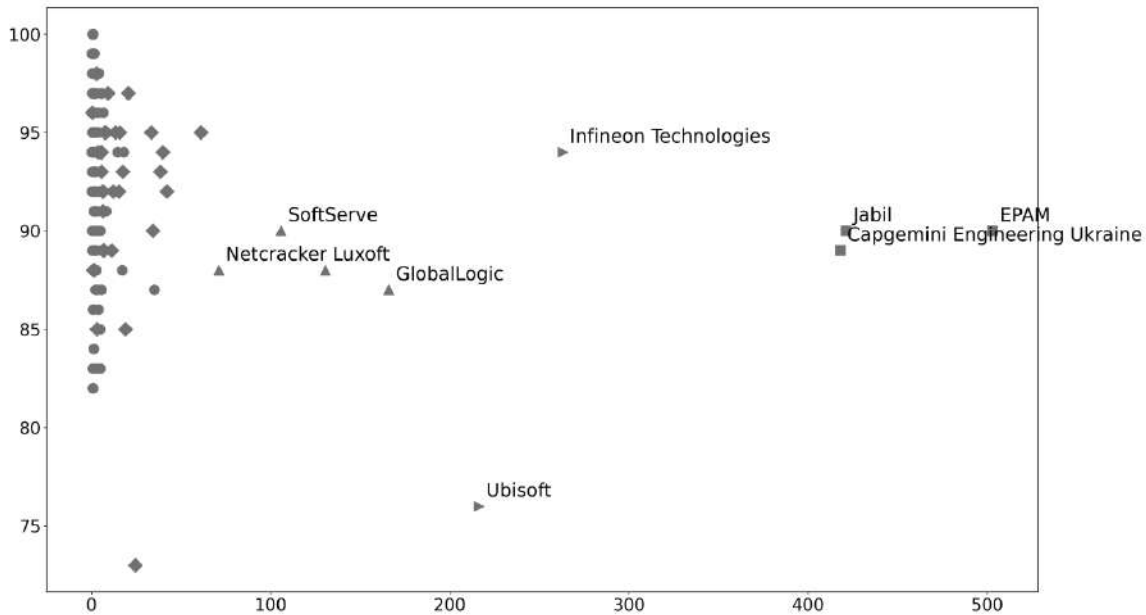
Figure 3. Clustering by scale and employee satisfaction index. The OX axis is the number of employees (in hundreds), and the OY axis is the consolidated index (average value) of employee satisfaction.

- The highest and lowest are the indices of satisfaction of employees of enterprises with the smallest number and with a large percentage of Ukrainian employees;
- Employees with more than 7,000 employees rated satisfaction as average (1-2 clusters). Exceptions are Ubisoft with 21636 and 3% Ukrainian and Playtech with 630 employees and 26% Ukrainian team members.
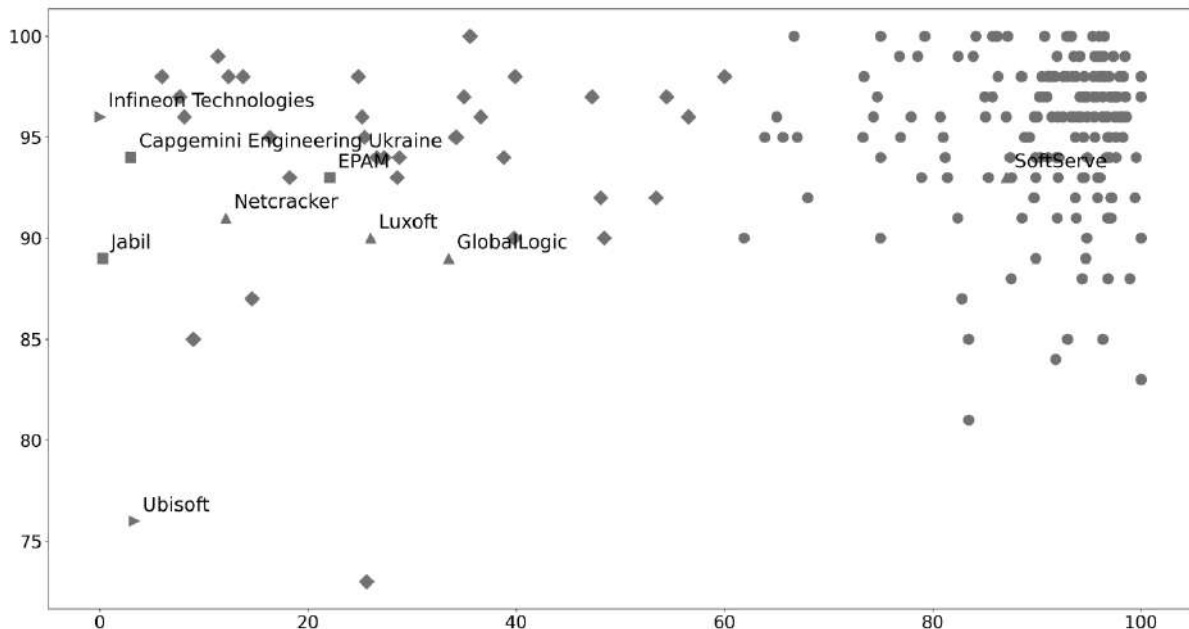
Figure 4. Two-dimensional representation of clustering results by satisfaction indices and enterprise scale. The OX axis is the percentage of Ukrainian employees, the OY axis is the Compensation category.

Figure 4 illustrates the fact that more than 85% of employees in almost all Ukrainian IT companies are satisfied with wages. Exceptions are the large company Ubisoft (3% of Ukrainian team members) and the medium-sized company Playtech (26% of Ukrainian team members).

Illustrations of the relationship between the percentage of Ukrainian workers and other categories of satisfaction indices are similar (Figures 5, 6, 7, 8).
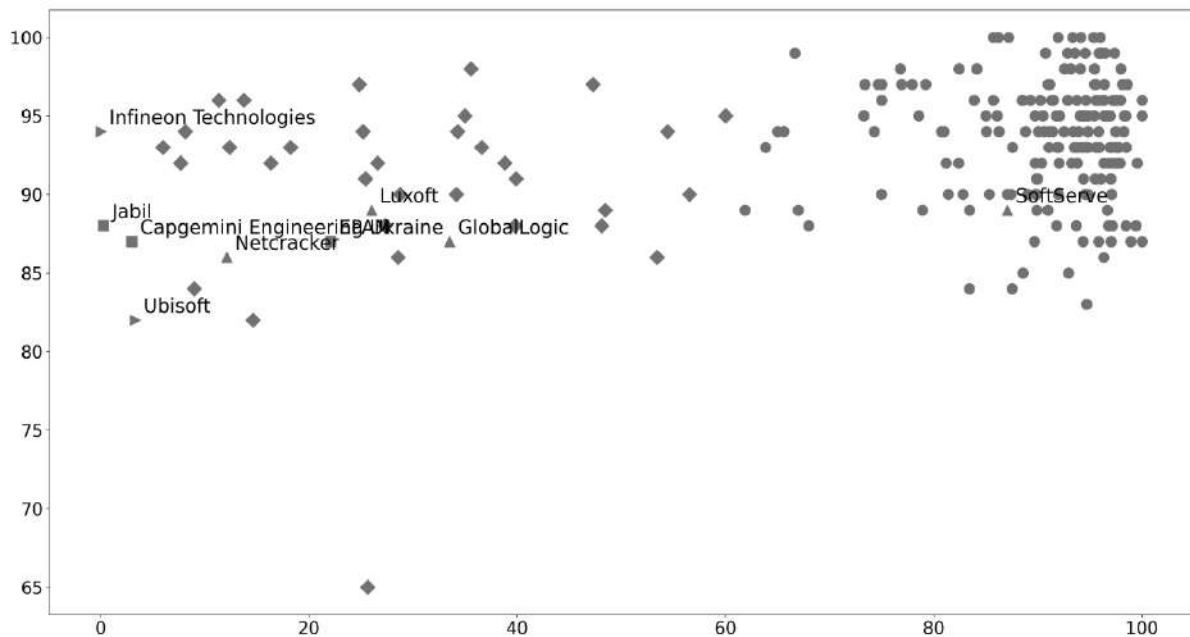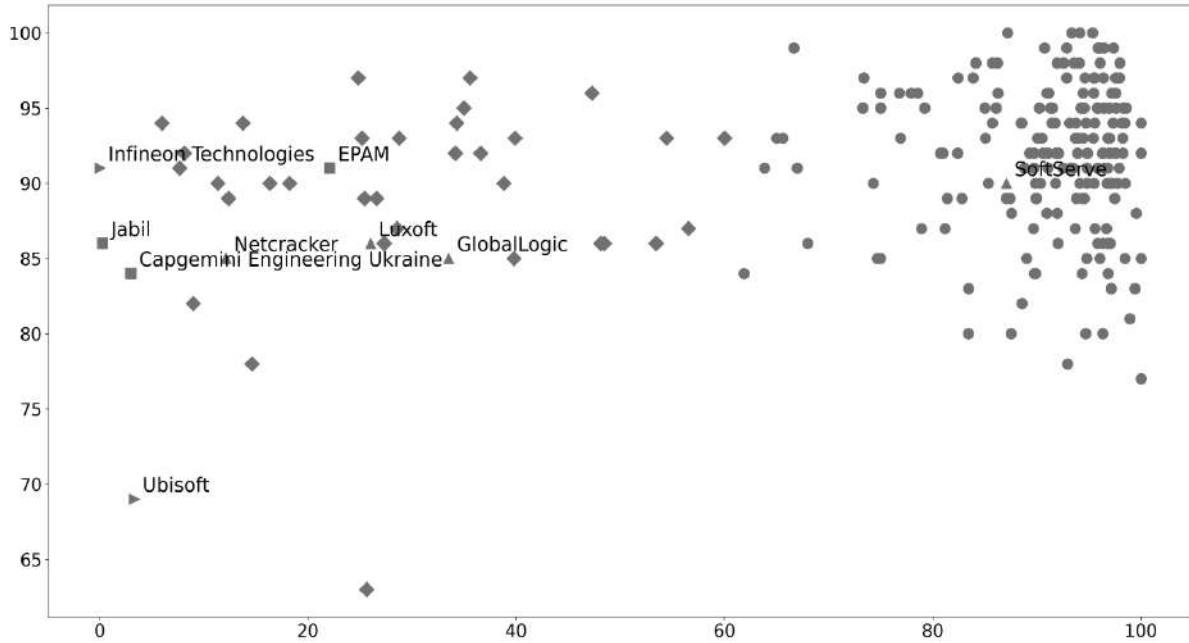

Figure 5. Two-dimensional representation of clustering results by satisfaction indices and enterprise scale. The OX axis is the percentage of Ukrainian employees, the OY axis is the Project Satisfaction category.

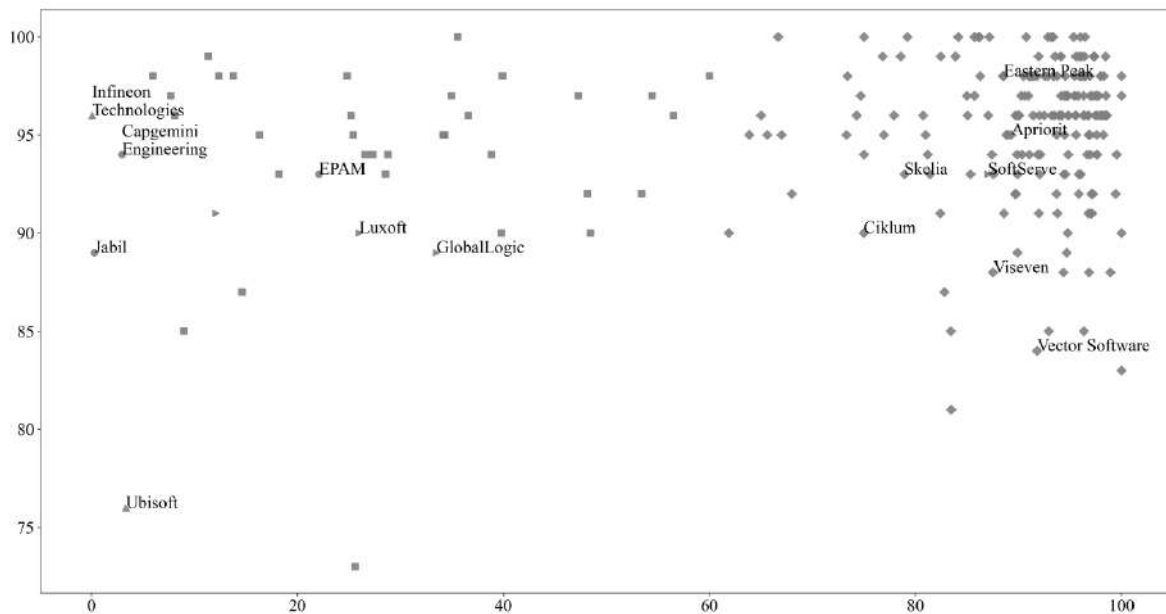The highest indicators of the index "working conditions":
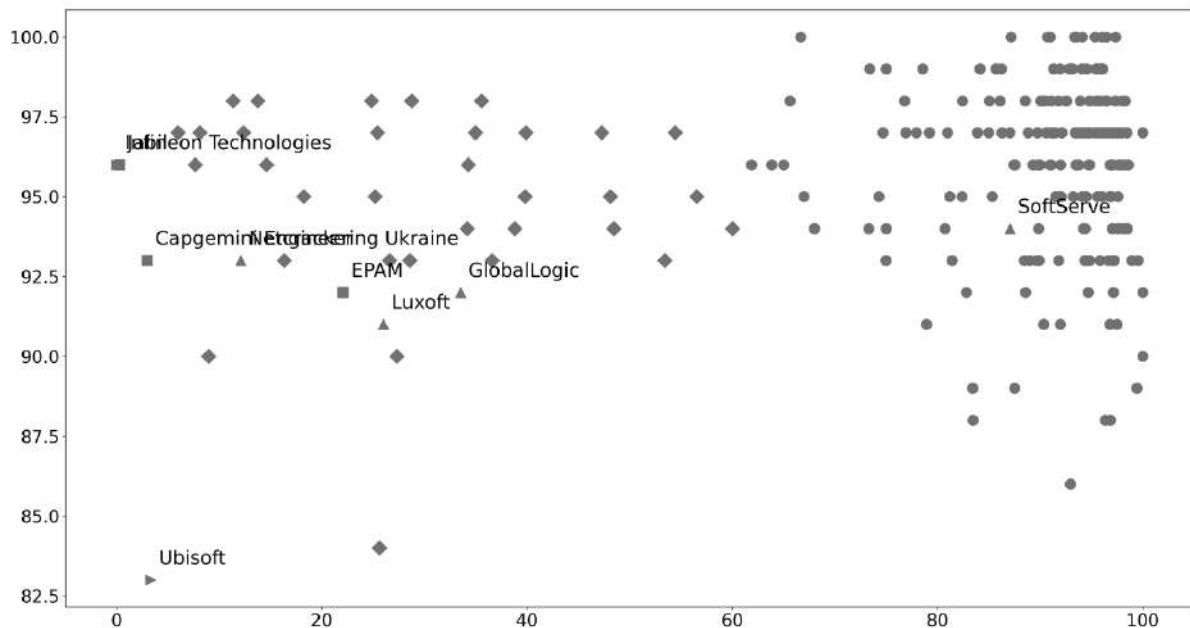
Figure 6. Two-dimensional representation of clustering results by satisfaction indices and enterprise scale. OX axis - the percentage of Ukrainian workers, OY axis - the category of "Working conditions".

Significantly fewer companies have rated their career opportunities at 100, but leading companies such as EPAM and SoftServe are in the 90+ group (Figure 7).

Figure 7. Two-dimensional representation of clustering results by satisfaction indices and enterprise scale. The OX axis is the percentage of Ukrainian employees, the OY axis is the "Career growth" category.

Figure 8. Two-dimensional representation of clustering results by satisfaction indices and enterprise scale. OX axis - the percentage of Ukrainian workers, OY axis - the category of "Loyalty".

5. Discussion

The obtained data recorded the fact of a high level of assessment of the components of motivational management by employees of IT companies that position themselves as Ukrainian. Three companies were registered, which showed 100% satisfaction with all five indices. All these companies belong to the group of 50 - 250 employees, with more than 85% of Ukrainian team members. The lowest recorded indices exceed 73%. This indicates that company management evaluates employee motivation as an important factor in deciding on staffing. Centroid values for each

indicator showed a small variance. This means that motivational management works evenly on all indicators quite uniformly, without significant advantages of some aspects over others (Figure 2).

The lion's share of companies with a high (about 95%) overall satisfaction index (average of all indices) is small companies. Large companies with high (SoftServe - 87%, Intelias-98%, Infopulse - 97%, Elex-90%, Genesis Tech -94%) and significant (EPAM, GlobalLogic, Luxoft, NIX, DataArt (about 22-57%) The share of Ukrainian workers in them shows a level of satisfaction of about 90% (Figure 3).

The joint clustering of these data showed a significant relationship between the percentage of Ukrainian employees in the company and all satisfaction indices without exception. Thus, companies with a low share of Ukrainian employees show a low level of salary satisfaction (Figure 4).

Joint clustering according to the same indicators proves the independence of the project satisfaction index from the percentage of Ukrainian employees. (Figure 5).

Only companies with more than 80% of employees registered in Ukraine show high satisfaction with working conditions.

Career satisfaction is slightly lower.

6. Conclusions

The study allowed us to conclude that large IT companies with a high and significant share of employees registered in Ukraine, carry out motivational management at the appropriate level. Companies with almost 100% Ukrainian team members show the highest level of satisfaction in all indices. Specialists in the Ukrainian IT industry are well motivated. Lack of motivation is not a deterrent to the potential growth of the industry. Thus, it is proved that the low level of motivational management in the segment of IT enterprises with high and medium shares of domestic specialists is not a deterrent to the potential growth of the industry. This result confirms the prepared and published conclusion of the Center for Economic Revival [5]. That is, the reasons for the lack of skilled workers involved in the field of information technology lie in the educational field [18], as well as in recruitment and branding methods. Further research will address the relationship between the description of the indices (both total and each in particular) and the growth rate of the company, as well as the dynamics of the pace of training of specialists in the field of information technology. The issues of recruitment strategies and process optimization, as well as the impact of the level of development of the employer's brand on the growth rate of IT companies in Ukraine, require additional consideration. The results of previous and subsequent studies will allow for building a fuzzy logical model [19] of the effects of a set of factors on the growth rate of the Ukrainian IT market in general and individual enterprises in particular.

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