

CLUSTERING IN BUSINESS ENVIRONMENT

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Abstract. *The mechanism of rational integration of business environment with the use of cluster approach is proposed. A clustering algorithm has been developed that takes into account the structural-logical sequence of operations in a business environment. The main advantages of business environment clustering are identified.*

Key words: *clustering, business environment, clusters, cluster approach, clustering algorithm, hierarchical cluster dendrogram.*

Introduction. The actuality of the researched theme is firstly confirmed by the increasing of the requirements for the function of rental business-environment, qualitative using of the resources, output of rival products, services for the markets etc.

Among the main Ukrainian external-economic perspectives the integration of the country to EU persists in recent years. That's why the using of the cluster approach can hasten an integration process notably, whereas, as practice has proven, this model is strongly used by the majority of EU countries. The constant clustering increase in the international economic structure is caused by the factor of global manufacture. As a distinctive feature of modern international economy is the acceleration of integration processes, so the economical theory and practice introduce a great number of variants and forms for business integration.

Despite the undoubted international practice of effectiveness, cluster organizational technologies in Ukraine are rarely used. However, even if there are some attempts in our country to apply cluster approaches to the structural

adjustment of industrial production, the official methodological approaches to the formation of clusters / structures have not been developed to date.

Research goal is to work out the sequence of the operations for the hierarchical clustering in the business-environment and the mechanisms of its realization.

Review of the latest research and literature. The problems of making cluster`s form activity is regarded in the research works of foreign and domestic scientists: A. Marshall, M. Porter, P. Samuelson, B. Burkinsky, O. Amosha, L. Fedulova, M. Sharko, V. Parsyak, E. Beltukov, B. Kvasnyuk and others. However, at the moment a lot of issues have been stayed, among those it is obligatory to admit the necessity of clustering foundation, innovative approaches and methodical workbench how to run integrated corporative business-structures.

In spite of such cluster union`s progress there are some cases, when the construction of them was found out as economically profitless. This, first of all, is conditioned by the absence of theoretical developments and the methodical recommendations as for the formation such unions, the calculation of clustering`s quality and the sequence of the construction for getting the best clustering. Therefore any steps to solve the mentioned problem are extremely necessary and useful.

A large number of scientists, such as [1-6, 8], who are trying to demonstrate that the nature of most elements and indicators, the use of resources as a whole determines the effectiveness of the functioning of business structures, investigates the problems of constructing clustering of the business environment. And this requires the search for fundamentally new innovative approaches to technical diagnostics and the organizational structure of international business.

Despite numerous studies, the diversity of scientific opinions about the process of cluster recognition, which includes understanding the essence of the cluster as a phenomenon, its main characteristics, along with flexible, dynamic boundaries, the dependence of its structure and features from the stages of the life cycle, the diversity of manifestations in the external environment, leads to the fact

that the cluster research stages (identification, primary diagnostics, designing), in principle, do not have theoretically justified methodological support [9].

Structural transformations of the global economy force existing companies to seek new fundamental forms of management, which include cluster associations. There is the possibility of finding adaptation opportunities for enterprises of one cluster on the basis of closer links between them in comparison with the connections with enterprises of other clusters, which characterizes the possibility of obtaining additional competitive advantages and adapting the agglomeration of enterprises (V. Goncharov, L. Martynova) [10]. A partnership of interconnected enterprises may have a potential that exceeds the mere amount of their individual potentials. This allows combining co-operation and competition, reducing costs, that is, use the synergetic effect of clusters (G. Ivanchenko) [11]. If use a cumulative assessment of the integral indicator of the competitiveness of a particular industry, and on this basis of the integral indicator the development of cluster type business networks in the region can be quickly promoted (V. Semenov, O. Bilaga) [12].

M. Boyko, G. Mikhailichenko suggest: "In order to develop effective measures for the development of economic complexes in the region based on the cluster concept, it is necessary to identify the industries that have the best conditions for the creation of a cluster" [13, p. 19].

Unfortunately, the question of the economical feasibility and the theoretical justification how to join the cluster unions of the international enterprises with different types of property, territorial location of these business structures are worked out not enough, that`s why often empirical cluster`s formation doesn`t give the expected results. Therefore it can be considered that formation of the general clustering system with the hierarchical subordination from territorial to international integration unions are referred to unsolved parts of the general problem how to make the clustering within the international business-environment.

Task setting. The following scientific tasks have been set out to achieve the target goal: formation of the general clustering system with the hierarchical

subordination from territorial to international integration unions are referred to unsolved parts of the general problem; definition of clustering through the function of intercluster distance and rarefaction; determining the benefits of clustering.

Statements of main issues of the study. Unlike traditional clusters, innovative clusters interact not only between companies, suppliers and clients, but also knowledge institutes, including research centers and universities [5]. This makes it possible to coordinate efforts and financial resources to create a new product, technology and enter with them into the international market.

In fact, within the cluster, it is possible to build a closed technology chain - from product creation to production and market entry. The main objective of using clustered activities is to increase the competitiveness of its participants in business structures through cluster collaboration, research, innovation, education and international support. Formation and functioning of clusters is aimed at accelerating the dynamic and effective socio-economic development of countries in which international business structures operate.

The criterion of clustering is such grouping of objects, which have the smallest distance between them.

To define the distance between business-structures in a cluster we will denote through C_i and C_j private clusters in a general clustering C , and intercluster distance between them through $d(C_i, C_j)$. There is a definite set of objects in the structure of every cluster, that make from enterprises manufactures, business-structures of procurement source and resources processing γ , i.e $C = \{\gamma\}$ i $C' = \{\gamma'\}$. Then with taking into account notations entered:

$$d(C, C') = d_f(\gamma, \gamma') \quad (1)$$

where: d_f – a measure of distance between objects γ i γ' .

In such a statement, in general terms, the difference between enterprises of the business-environment C and C' can be introduced as a function F paired

distances between the objects, when one of the objects belongs to the cluster C, and other – to the cluster C', i.e.:

$$d(C, C') = F(\{d_f(\gamma_i, \gamma_j) \mid \gamma_i \in C, \gamma_j \in C'\}) \quad (2)$$

Function F, that defines a distance between two clusters can be specified on the assumption of minimal distance between the closest members of two clusters:

$$d_{\min}(C, C') = \min(\{d_f(\gamma_i, \gamma_j) \mid \gamma_i \in C, \gamma_j \in C'\}) \quad (3)$$

Using this function, clusters can be obtained, in which every object corresponds to the objects of its cluster, than the objects of other cluster. One of the problems, appearing when we use given function, is an opportunity for creating of expanded extended clusters. It will result in that, objects, which are on the opposite sides of one and the same cluster, will not be similar.

Another approach for setting function F, based on the determination of maximum intercluster distance between two clusters:

$$d_{\max}(C, C') = \max(\{d_f(\gamma_i, \gamma_j) \mid \gamma_i \in C, \gamma_j \in C'\}) \quad (4)$$

This function allows to create clusters, however, if real groups of objects have extended form, so received clusters can be inadequate.

And there is a probable method for defining distance between clusters by defining arithmetical mean between all objects in pairs:

$$d_{\text{avg}}(C, C') = \frac{1}{|C| \times |C'|} \sum_{\gamma_i \in C} \sum_{\gamma_j \in C'} d_f(\gamma_i, \gamma_j) \quad (5)$$

Every of these functions has its disadvantages and advantages and it is acceptable for clustering different types of clusters. At the beginning it is difficult to define to what type of integration union it is reasonable for relating existent

enterprises. It demands additional expert appraisal. For this, it must be defined a type of the function, that is used for defining intercluster distance.

For the whole clustering $C = \{C_1, C_2, \dots, C_n\}$ a distance of clustering 3 function, as middle intercluster distance between distance C_i and C_j in clustering C :

$$D(C) = \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n d(C_i, C_j) \quad (6)$$

The further one cluster is located from another cluster, the bigger distance of clustering. It means that a distance of clustering is a function of clustering process itself, and not separate pairs of clusters.

An important arrangement of clustering is exactly tightness of clusters placement inside cluster, and between different clusters in clustering, i.e. rarefaction $r(C)$. To define it we should input quantity, that characterize a center of cluster's mass h_{med} . Then for cluster 3 rarefaction will be defined as a middle distance between elements of cluster and its center of cluster's mass:

$$r(C) = \begin{cases} 1 & , \text{if } |C| = 1 \\ \frac{1}{|C|} \sum_{i=1}^{|C|} df(h_{med}, \gamma_i) & , \text{if } |C| > 1 \end{cases} \quad (7)$$

For the whole clustering system $C = \{C_1, C_2, \dots, C_n\}$:

$$R(C) = \sum_{i=1}^n r(C_i) \sum_{j=1}^n r(C_j) \quad (8)$$

A rarefaction of general clustering has high significance, if it consists of rarefied clusters, and, on the contrary, it can be low, if there is a large density of its placement. In general clustering quality is defined as function $R(C)$ i $D(C)$:

$$Q(C) = \frac{D(C)}{R(C)} \quad (9)$$

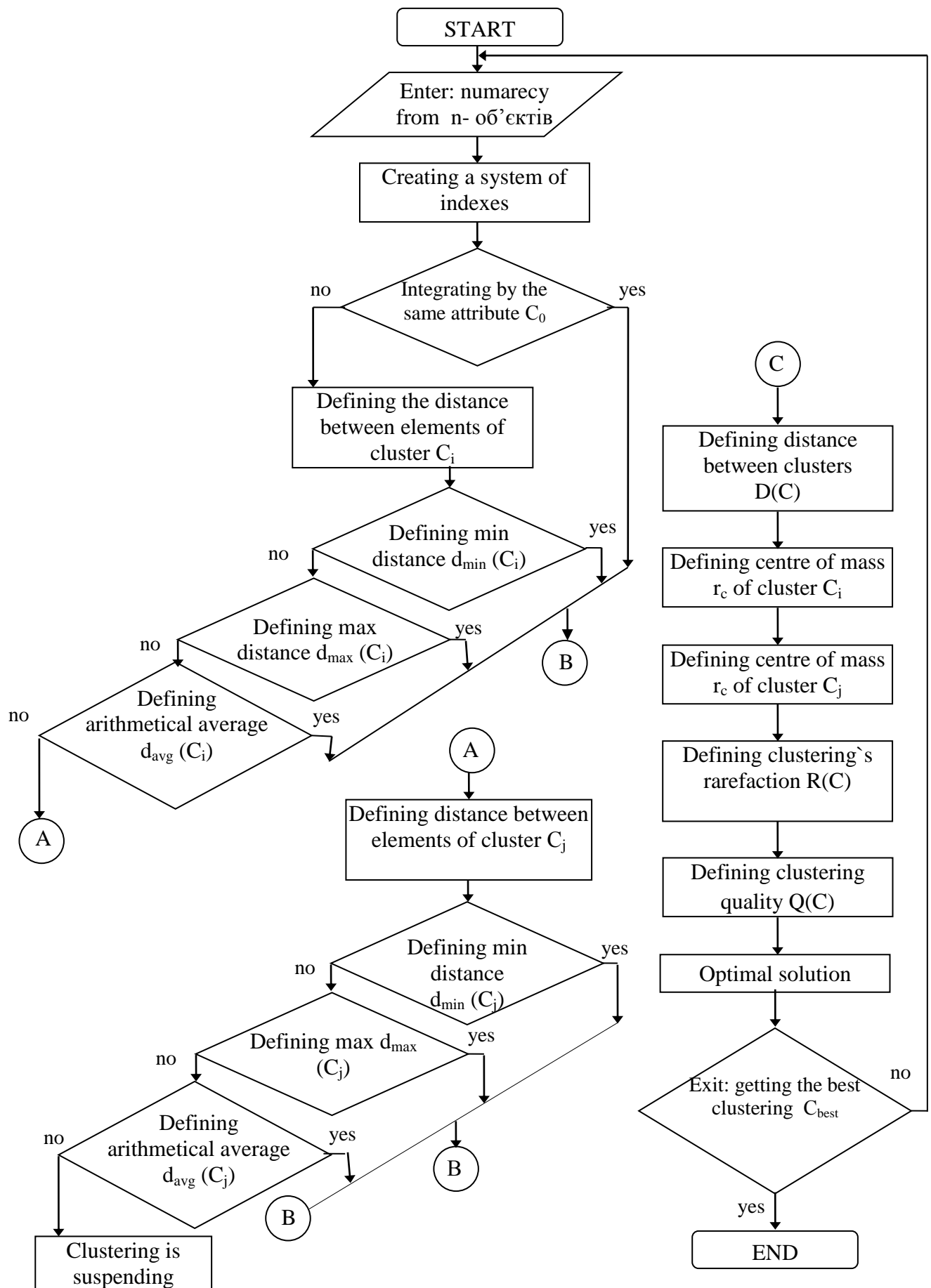
It formulates requirements for clustering formation. The use of quality clustering arrangements permits carry out clustering process, using functions of intercluster distance, and further, using quality level of every clustering, optimal

one is chosen. The application of quality clustering arrangements eliminates the necessity of inputting as an entry parameter threshold value of similarity, which usually is appointed by experts.

It was worked clustering algorithm by authors, that takes into account structural-logic sequence of mentioned operations, in which as an entry parameter a plenty of n object or enterprises are used, recommended to be participated in cluster education (pic. 1).

Where: n –objects clustering begins with making the simplest hierarchical union by one elementary attribute C_0 . If union is turned out incomplete, it will be made necessary set of following actions: include operations of metrics formation and consistent distance calculations between elements of cluster C_i , in which minimal and maximal distance between elements are defined, and also arithmetical average of their distances, after then similar calculations are made for another cluster C_j , and if it's necessary – for others. These data are the basis for determining such important clustering parameters a distance between clusters in clustering $D(C)$.

Next, sequentially calculating a center of cluster's mass $r(C)$ clusters C_i and C_j , subject to a middle distance between members of these clusters, we figure out clustering rarefaction $R(C)$ and, using meaning $D(C)$ and $R(C)$, define the clustering quality $Q(C)$. Optimization of solutions allows to define a type of function, that is used for intercluster meaning of distance, and meaning of the best clustering C_{best} . Basic data are optimal clustering C_{best} , that is the best one, from the point of view concerning clustering quality $Q(C)$.



Pic. 1. Algorithm of structural-logic sequence operations of hierarchical clustering in business-environment

The necessity to solve a problem of supporting managerial decisions by estimating of enterprises function efficiency in business-environment demands to use of economical-mathematical methods. Using a number of methods, methods of networking planning, methods of researching the operations when the decisions are making as for economic and innovative international manufacture gives an opportunity to up build an optimal hierarchy for management levels in the conditions of dynamic and transformation changes of external environment and make and work out configuration of management system, that is referred to obtainment of maximum effect due to optimal recourse placement and proper relevant staff allocation of in business-environment.

Clusters occupy a special place among autonomic organizations, regional industrial complexes, brunch alliances and TNC, using the concentration within local territories and the concentration, based on the cooperation with internal consumer ship and determinative innovative orientation, cooperation of being involved related industries for providing competitiveness on the international market due to high productiveness, that has its background in the specialization and the interaction in participating of business-environment`s cooperation [5].

The specific characteristic of clusters is that, the effects, related with its creation, provide the advantages, which can`t be provided with the company only. For instance, Marshall, “father of clusters” determines such exterior effects (externations) as uniting of special labour resources, more variety of specialized local or international goods and services, spread of knowledge, that takes place through formal and informal ways. The above-mentioned advantages can spread beyond one cluster and due to synergy cause the creation of new cluster. This, in turn, makes the unique competitive advantages on the local and global levels, that intensify cluster/territories integration into global delivery chains [1].

The history of cluster development, as high concentration zone of international business-environment`s subjects, goes far to the past – it is a cluster of marine vessel building in the Netherlands and automobile clusters, which have appeared almost at the same time as the vehicle manufacturing industry have been

founded. In the USA – it is Detroit automobile cluster, that was appeared around the three largest American giants of motor vehicle industry: «General Motors», «Ford» i «Chrysler». Also Detroit is known for its automobile exhibition, that promotes innovative development of the USA automobile cluster [7, c. 138].

Going into a cluster increases company`s status, promotes to increase attention from financial agencies, its international reputation expansion and popularity of trade mark, draws supplementary resources to the region (state). In its turn, cluster`s presence enhances the region administration role, whereas it develops and strengthens its regional economics, stimulates economic advance and accelerate social problem`s solvation, creates conditions for successful development of more backward territories.

Companies` experience, that have introduced cluster approach in one or the other form, took them to a new level of economic growth. Manufactured production is worldwide competitive. High-technology cluster approaches are used in many countries within different fields. And globalization as a factor of modern as state-to-state relations, amplifies new technology interchange, innovative interexchange, and so it has made ordinary consumers usage of them possible.

Having regard to all before-mentioned, we may define clustering like: firstly, cluster particularity is getting synergetic effect by companies, that is expressed in increasing competitive recovery of the whole system comparing to separate economic agents. Cluster mechanism of competitive recovery is based on efficient unification of intra-cluster cooperation during process of production with the internal competition. Herewith, a chain nature of its participants cooperation (horizontal integration) promotes creation of oriented chain for new knowledge spreading, technologies and innovations.

Secondly, the most successful clusters are formed there, where “breakthrough” in technics and production method is being realized or being expected with further expansion to new “market niches”. According to this a lot of companies use “cluster approach” more actively to set up and control its innovative programs.

Thirdly, maintaining cluster politics is based on cooperation between governmental authorities and bodies of local self government, business-environment and academic institutions for coordination of efforts as for innovative manufacturing raise and service industries, that promotes mutual enhancement and raise working effectiveness. Then, it can't be forgotten, that innovated clusters have advanced relations with similar clusters in other regions and countries. Stimulating such international ties becomes an important direction of cluster politics and it is considered in the cooperation development between allied clusters, elaboration and realization of cooperation development programme. Fourthly, clusters don't develop separately, but involve to their development a professional qualification, an involvement, a sufficiency level. As a result, life level and life quality increases in the region, in the country.

As the task of business-environment development adds up to clustering in n-dimension area, so clustering is implied the process of creating set of objects as clustering, that have high inner cluster similarity and low intercluster one. These are the objects, which belong to the one cluster, they are more alike to each other, than to the objects, that belong to other clusters [5].

The division of two objects being grouped to the clusters defines due to some similarity measure. Defining similarity measure it must be taken into account, that its attributes can have different nature, that is they can be numeric, nominal, categorical etc. The similarity between the objects is defined on the base of measuring the distance between them. The higher level of similarity two objects have, the less distance must be between them [5].

Designated thing is proved obviously, that foreign IT-companies transfer to Ukraine actively: American Lohika Systems, Inc., German N-iX, Spanish Grupo Delaware ra Ulybin, Danish Mita-Teknik etc. And, for example, such international companies as AltexSoft, INSART, Promodo, Sloboda Studio, Telesens and Videal are included to Kharkiv IT-cluster. The main thing is that, what these companies are interested in, is a lot lower social expenses on highly qualified informative workers in comparison with countries of Western Europe or the USA. Also about

this statements of representatives of created clusters on the broad lands of Kharkiv area are declarative of that near 90% individuals, that work in the regional IT-cluster, are registered by sole traders. And labour law in force is archaic, not flexible one, provides for some difficulties as for dismissal or consolidation of specific conditions in the contract. Given positions prove single-valued direction of the interests of cluster founders (whatever they are: industrial or innovative) to search for cheap reserves of labor force and weak standards for its social protection, that minimizes expense of investors and increases its profits [3].

To develop cluster concept co-opetition is important: when international companies, that are competitors, at the same time work over joint strategy. One of the examples – food cluster on the south of Sweden. They regularly gather executive general managers together, in order to create open environment, where competitors can discuss joint questions, generate collective strategy for the whole cluster. They have board of the company, that is managed by business, however representatives of government institutions and universities are included to it. Also serial entrepreneur is included there, he has founded a lot of food companies, and now he supports small start-ups. Such board of directors provides “triple spiral” and allows a cluster to move with the speed of the international business – environment [4].

Cluster enterprises are highly innovative. A common feature of clusters that have made significant technological progress is that all participants work as elements of the network, not alone.

The dissemination of multidimensional statistical analysis methods as a tool for strategic management opens up wide opportunities for modeling, analysis of phenomena and processes, characterized by a large number of characteristics and performance indicators of production activities. The competitive advantages achieved at the same time are ensured by the exchange of resources, information, formation of development strategies on the basis of supply and demand, additional services, employees for basic pricing. Clustering refers to the process of finding groups of objects that have a high intracluster similarity, that is, objects belonging

to one cluster are more similar to each other than to objects belonging to other clusters.

Thus, the task of clustering is to divide the studied set of enterprises into groups with similar properties or attributes. To classify the business environment, it is suggested to use Ward's hierarchical agglomerative method using the Euclidean metric.

For a small number of factors characterized by two variables, the results of the cluster analysis are represented by dots. The decisive criterion for determining the similarity of features is the distance between the points on the scatterplot. The definition of clusters and the distribution of objects according to them is expressed in the final data model, which is the solution to the clustering problem.

As a result of cluster analysis, groups of observations are formed using pre-defined variables. Clustering aims to identify local condensations of production objects by defining characteristics, considering that the objects are set in metric space X with metric p .

The task of clustering the business environment can be defined as follows: it is necessary to group the enterprises into a cluster in such a way that the distance $d(K_i, K_j)$ between different clusters must be large and between the objects of one cluster small, so the functional F should be minimized [5]:

$$F = \frac{\sum_{i=1}^n \sum_{x^t, x^j \in K_i} p(x^t, x^j)}{\sum_{1 \leq i < j \leq n} d(K_i, K_j)} \quad (10)$$

The hierarchical merger process is visualized on the dendrograms. An example of building a dendrogram is shown in pic. 2.



a) Starting position of points

b) Dendrogram of Single Link method

Pic 2. Construction of a hierarchical clusterization dendrogram. [5]

The graph clustering algorithm is based on the construction of a minimum spanning tree of minimum length connecting all points. After constructing such a graph, the longest edges are removed from it. The remaining components are declared by clusters (pic. 3).



Pic. 3. Minimum spanning tree and two clusters formed after removal of longest rib. [5]

The big advantage of cluster analysis is that it allows you to split objects not by one parameter, but by a whole set of features.

The formal formulation of the cluster analysis problem is based on many data objects I , each represented by a set of attributes. Multiple clusters need to be built C and display F plural $I = \{i_1, i_2, \dots, i_j, \dots, i_n\}$, where i_j - object under study, on the plural C , that is $F: I \rightarrow C$. Reflection F specifies the data model that is the solution to the clustering problem.

Cluster formation conditions are geographical proximity, general activity, efficiency and effectiveness.

The dendrogram visualizes the merger process shown in the agglomeration table. It identifies the merged clusters and the values of the coefficients at each step. This does not reflect the original values of the coefficients, but the values given on a scale from 0 to 25 clusters obtained by the merger, and are displayed by horizontal lines.

In the first partition, all objects are divided into groups closest to the center. Proximity is determined by the distance to the center and its regulatory characteristics. The Euclidean distance, which is determined from the transport portal data, is used as linear measures. It is assumed that the cluster always has a

nodal point, which is the center of the cluster, the degree of belonging to which the cluster is equal to one, while the boundary equals zero.

In the second step, the new cluster centers are calculated. They can be defined as the average of the variable objects assigned to the formed groups. This operation is repeated recursively until the cluster centers cease to change. In this case, the partition will be the last.

Since clustering is performed from the individual elements from the bottom to the top, the agglomerative hierarchical clustering method is used. Thus, in the process of clustering, clusters are combined and the number of clusters is further reduced.

Conclusions. Represented algorithm of structural-logic sequence operations of hierarchical clustering business-environment, in contradistinction to existing ones, provides an objective analysis of advantages and disadvantages of cluster uniting of enterprises, defines the most foreground directions of estimating as for placement of its elements, determines organizational actions and enhances the effectiveness of enterprises functioning adjusted for the correlation and estimates of effectiveness indicators for manufacture functioning.

A quality definition of clustering through the function of intercluster distance and rarefaction allows to choose an optimal clustering. Using this characteristics excludes the necessity enter as input parameter threshold value of resemblance, that usually is assigned by the expert. As for using clusters in international business -environment, so they are accompanied by the major motivating goals:

- firstly, clusters appear like agents of «reorganization» for domestic (regional) economics, and that`s why they have commercial concentration and belong to peculiar exceptional strategy. After all, a development of clusters is prior for high-tech branches exactly.

- secondly, clusters promote activation of business-environment within international scale.

Competitiveness of clusters depends on its ability to adapt to changes of business-environment. That`s why cluster has flexible architecture and with

minimal expenses rearranges according to exterior demands. Including a new participant changes a structure of competencies of cluster without necessity of its physical restructuring. Thus, the absence of dependence on geographical placement allows companies to take part in several clusters at the same time or develop own cluster in international space, that provides access to needed knowledge and competencies. An advantage of cluster is conveyed in an ability to work out effective structure of relationship with the international partners. Along with it constant cross-disciplinary and cross-cultural interaction occurs in a cluster, as a result of which significant innovations are able to arise and perspective international projects can be realized.

We can state surely, that clusters provide export of manufactured goods development in the business-environment. Today numerous examples from world practice became confirmation, that cluster form of organization concentrated manufacture and co-operation is the most prepared for any innovative process.

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КЛАСТЕРИЗАЦІЯ В БІЗНЕС-СЕРЕДОВИЩІ

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Анотація. Запропоновано механізм раціональної інтеграції бізнес-середовища із застосуванням кластерного підходу. Розроблений алгоритм кластеризації, який враховує структурно-логічну послідовність операцій у бізнес-середовищі. Визначено основні переваги кластеризації бізнес-середовища.

Ключові слова: кластеризація, бізнес-середовище, кластери, кластерний підхід, алгоритм кластеризації, ієрархічна дендограма кластера.

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