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SPATIAL ORGANIZATION MANAGEMENT: MODELING THE FUNCTIONING OF ECO-CLUSTERS IN THE CONTEXT OF GLOBALIZATION

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Abstract

The issue of spatial organization of eco-clusters has always been under the close attention of scientists. Greening of production, resource conservation, economical use of natural resources, increasing the greenhouse effect and industrial emissions are forcing market stakeholders to plan cluster associations aimed at minimizing the negative impact of human activities on the environment. At the same time, this issue is extremely complex and needs careful study. In particular, the concept of formation and location of eco-clusters in the context of globalization should be based on the institutional environment, legislative field, labor market and other territorial conditions where the eco-cluster is planned to be located. It is important to form a cluster core, which will be the administrative center of eco-cluster management. In this regard, the purpose of the article is to model the activity of eco-clusters based on a neural network approach to the management of their spatial organization.

In this research, on the basis of training a neural network using regional indicators of institutional support and development of the labor market, the solution to the problem of the spatial organization of eco-clusters on the territory of Ukraine is described. The authors used the tools of artificial intelligence to model the spatial location and organization of eco-clusters. They proceeded from the premise that in each territory there is a certain set of labor, institutional, production, technological, managerial and information resources, the successful use of which will allow to effectively modeling cluster associations, and propose to recombine eco-clusters using the method of neural modeling. The input data for modeling eco-clusters is the use of 3,102 units of indicators by the neural network, which characterize the institutional and resource provision of a particular region of Ukraine. Given the wide range of input digital data, their various definitions (absolute or relative) neural network makes it possible to automatically summarize and organize them. After completing the training of the neural network, analysis of errors and deviations, we obtain spatial graphical images of the optimal location of eco-clusters in Ukraine. The proposed neural network approach makes it possible to optimize the process of economic and statistical modeling of a significant array of data characterizing the main parameters of the environment in which ecological cluster associations operate.

The trained neural network allowed obtaining a map of the optimal location of eco-clusters, taking into account the available in a particular area of institutional, informational, innovative, technological and other types of resources. Based on the theory of synergetic systems, such a spatial arrangement of the eco-cluster will allow in the best ways to use available resources for their accumulation and multiplication in the cluster. The proposed neural network approach makes it possible to optimize the process of economic and statistical modeling of a significant array of data characterizing the main parameters of the environment in which ecological cluster associations operate.

The method of spatial modeling of eco-clusters proposed by the authors using the tools of artificial intelligence allows determining the best administrative centers of cluster development that can strengthen the territorial socio-economic development based on innovation and economical production. The step-by-step process of eco-cluster modeling presented by the authors will allow all stakeholders interested in the market to use artificial networks in the process of planning progressive spatial development. In addition, the proposed method of modeling eco-clusters, neural network activation and training do not require significant financial, technical and labor resources, which is a positive phenomenon in the context of ensuring resource-saving development of any area.

***Key words**: Environmental management, Spatial organization, Labor Market, Institutional Development, Neural Network, Model.*

1. Introduction

In the context of globalization, characterized by rapid growth of competition in world markets, one of the priorities facing public authorities is the effective organization of economic activities of eco-clusters in the country, which, in turn, act as catalysts for innovative development and counteraction to the emergence of crisis phenomena in the national economy. At the same time, an important aspect in ensuring the effective functioning of eco-clusters is a reasonable choice of their location, which makes it expedient to carry out spatial recombination, which would take into account the institutional processes and opportunities of the existing labor market characteristic of a certain region of the country, as well as be based on the results of a timely analysis of efficiency of existing enterprises that can become cluster centers or "anchor" enterprises. In addition, there is a need to determine the type of clustering in which it is possible to realize the maximum synergistic effect from the overflow of knowledge within a separate territorial unit. In this regard, in order to stimulate clustering processes, it is necessary to adapt state regulation to the specific characteristics of the institutional environment in a particular country. Because it is the institutional diversity of national economies that contributes to the formation of their own form of state support, taking into account the existing national business models.

The scientific works of many scientists are devoted to the study of the innovation clusters formation, including environmental ones, their spatial organization and state regulation of their functioning [1, 2]. Thus, Lindqvist *et al.*, [3], developed an economic model of optimizing the functioning of eco-clusters and evaluating the effectiveness of their work. An article by Kuksa *et al.*, [4], considered the specifics of the mechanism of interaction between enterprises as part of an innovation cluster in a highly competitive environment. Feser *et al.*, [5], analyzed the impact of the activities of eco-clusters on the state of the environment and the development of the national economy. The article by Kayikci *et al.*, [6], considered the impact of four aspects (technology, manufacturers, consumers, government policy) on the functioning of enterprises participating in environmental clusters in the environmental industry. Spencer *et al.*, [7], developed a system for assessing the dependence of the competitiveness level of the regional economy on the geographical location of clusters. Souza *et al.*, [8], investigated changes in the nature of the influence of Brazilian clusters of ceramic tile manufacturers on the environment after the introduction of eco-innovations into their production process. The scientific work of Yoon and Nadvi [9], defined the role of institutional support and public authorities in achieving "environmental collective effectiveness" through collective action in the process of functioning of clusters in South Korea. Anh *et al.*, [10], proposed a physical and technological conceptual model for minimizing the negative environmental impact of an eco-industrial cluster for the fishing industry in Vietnam. Deutz and Gibbs, [11], considered ways to improve the efficiency of the functioning of eco-clusters as the main components in ensuring the stable development of the regions where they are located. Daddi *et al.*, [12], using the example of four clusters of the Tuscany region tested the economic model of environmental management, which would reduce the negative impact on the environment from the industrial clusters of Italy. The scientific works of scientists identify priorities for the development of entrepreneurship based on clustering and resource conservation [13 - 15].

Paying tribute to the above research works, it is worth noting the need for further research in the direction of optimizing the formation and geographical location of eco-clusters, taking into account the specifics of institutional support and the labor market in the territory of their location. In this regard, the purpose of the article is to model the activity of eco-clusters based on a neural network approach to the management of their spatial organization.

2. Materials and Methods

In this article, using the example of regional indicators of institutional support and development of the labor market, the solution to the problem of the spatial organization of eco-clusters on the territory of Ukraine is described on the basis of training a neural network in Statistica Automated Neural Networks (SANN). The proposed neural network approach makes it possible to optimize the process of economic and statistical modeling of a significant array of data characterizing the main parameters of the environment in which ecological cluster associations operate.

In order to determine among the studied regions of Ukraine, which can become the location of enterprises - cluster centers, the Prim's Algorithm was used, for the implementation of which territories with high levels of institutional support were involved.

3. Results and Discussion

In order to improve the management of the functioning of eco-clusters in Ukraine, we will consider the process of determining the optimal geography of their location using a neural network. The total number of observations that will be involved in the process of modeling the spatial organization of the eco-cluster was 1,800 units. Let us introduce the notation for all input variables: Var1…Var*n*. In accordance with the selected data, after launching the neural networks module - the Variables tab - we select categorical or continuous variables (Figure 1).

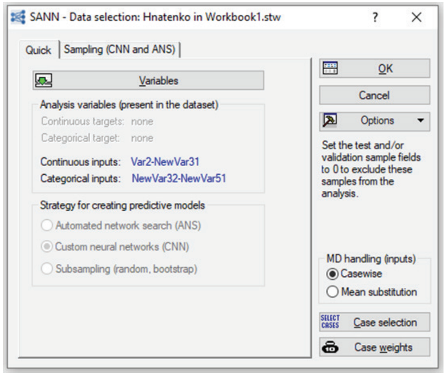


Figure 1. Distribution of selected data
Source: Displaying the results of data analysis by authors in Statistica Automated Neural Networks (SANN)

To model the eco-cluster, we used the parameters of the order of institutional development in the context of institutions across the territories of Ukraine, the results of which contribute or hinder the development of innovative activities of enterprises - its participants: Institute of Human Capital Formation; Institute of Financial and Credit Component Formation, Institute of the Implementation of Innovations in Industry, Institute of Intellectual Property, Institute of Infrastructure Support, Institute of Regulatory and Legal Support, Institute of Public-Private Partnership and Mediation, and Institute of Information Support.

To identify the appropriate formation of clusters taking into account the labor market, it was proposed to use the following statistical indicators: the level of the employed population aged 15 - 70; the level of informal employment; natural population growth; migratory population growth; the level of economic activity of the population; the number of infrastructural elements of the labor market; investment in the labor market; labor productivity.

For the neural network, in the Sampling tab, training, test and control samples were formed from the input data, which makes it possible to implement further steps in modeling an innovative cluster (Figure 2).

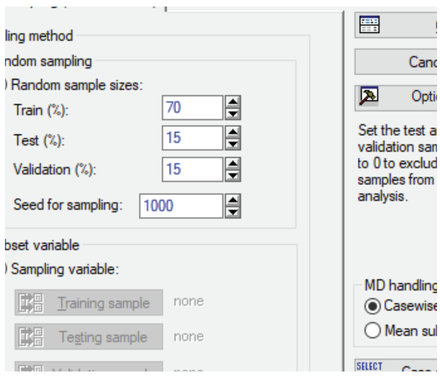


Figure 2. Dialog Neural Networks - Formation of training, test and control samples for a neural network
Source: Displaying the results of data analysis by authors in Statistica Automated Neural Networks (SANN)

Since the entire sample of integral indicators consists of studies in 25 regions (which contain categories that determine institutional development and the labor market), it was divided into three parts, 70% – for the training set, 15% - for the test set and 15% - for the control set. In order to distribute the analyzed parameters of the neural network in the SANN tab, we decide on the topological characteristics of the map and select the desired number of passes of training cycles. Since neurons train neighbors, the location of neurons is also important (Figure 3).

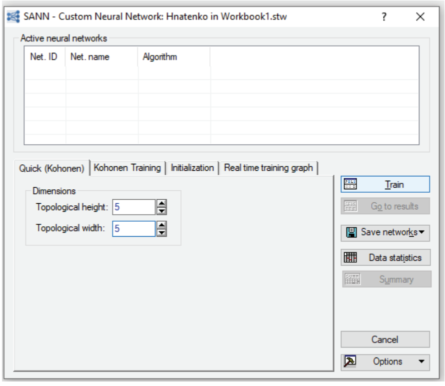


Figure 3. Selection of the desired number of neurons and their structure
Source: Displaying the results of data analysis by authors in Statistica Automated Neural Networks (SANN)

Next, it is necessary to determine the parameters of training the neural network in the enumeration process by choosing the number of neighbors that the neuron will train. At the same time, it is advisable to carry out such an enumeration until all groups of the desired eco-clusters are formed, with minimal system errors.

We analyze the training process of the neural network, which is presented as a learning set of a grouped set of input vectors, where the scales of the network are adjusted (Figure 4).

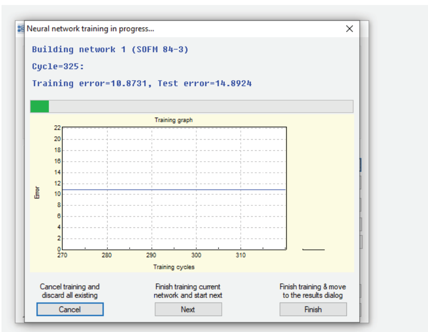


Figure 4. Window of neural network training results
Source: Displaying the results of data analysis by authors in Statistica Automated Neural Networks (SANN)

After the performed combinations, we obtain an expedient neural network (Figure 5). Thus, on the trained map, a spatial image of expedient clustering is observed with spectra that exhibit distinct properties that activate various neurons.

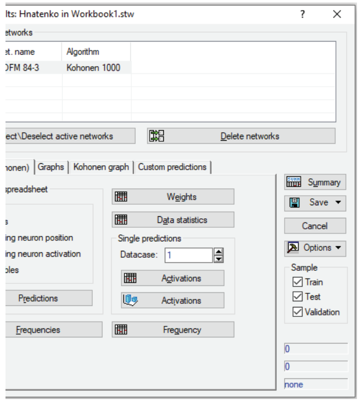


Figure 5. Neural network indicators
Source: Displaying the results of data analysis by authors in Statistica Automated Neural Networks (SANN)

The Predictions tab displays the results for each category with the coordinates obtained by the neural network (Figure 6). In the case of a more detailed need for neural network analysis, it is also possible to process individual observations and see how the topological map changes. This allows us to understand whether the clusters have meaningful components, divided into individual indicators.

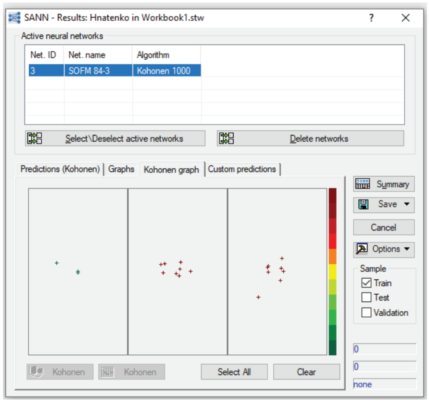


Figure 6. The obtained result of grouping prediction
Source: Displaying the results of data analysis by authors in Statistica Automated Neural Networks (SANN)

Using a neural network, it is possible to obtain a graphical representation of the obtained simulation results. The output frequencies of the data distribution by the neural network are as follows (Figure 7).

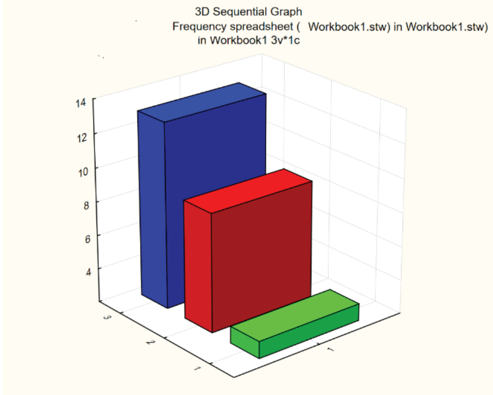
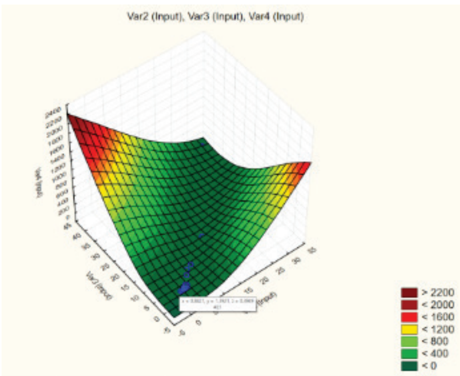


Figure 7. Output frequencies of input data distribution by the neural network
Source: Displaying the results of data analysis by authors in Statistica Automated Neural Networks (SANN)

The neural network predicts clustering for each combination of two metrics in a 2D image (Figure 8). The resulting graph of coloring the surface of the i-*th* feature in three-dimensional space, where the points are individual marks that are above or below the activation function.



Summary of active networks (Predictions spreadsheet (Hnatenko in Workbook1.stw) in Workbook1.stw)

Index	Net. name	Training error	Test error	Validation error	Training algorithm
3	SOFM 84-3	0.011752	0.13921	0.02121	Kohonen 1000

Figure 8. Graph of the response surface depending on two input variables and the results of training a neural network
Source: Displaying the results of data analysis by authors in Statistica Automated Neural Networks (SANN)

The surface, depicted in three-dimensional space, represents the response of one or more variables (in a neural network) depending on two input variables while the others are constant. The research made it possible to identify the features of the structure of eco-clusters and determine the centers of their development. According to the level of this activity, the territories were divided into three groups (territorial and sectoral clusters). In order to determine the Cluster Centers, it is proposed to use the Prim's Algorithm (Figure 9).

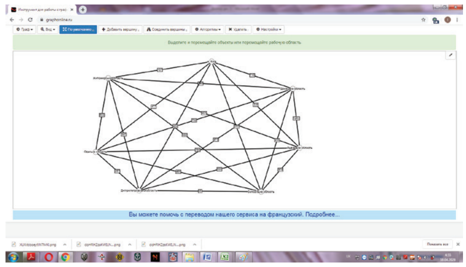


Figure 9. Implementation of cluster centers according to Prim's Algorithm
Source: Calculated by the authors

When calculating the algorithm, it is necessary to take into account the fact that in order to create competitive eco-clusters; there is a need to select only those Cluster Centers that have a sufficient level of institutional support. That is, for the implementation of Prim's Algorithm, it is advisable to involve only those territories where the level of institutional support is the highest. These regions of Ukraine include: Zhytomyr, Donetsk, Lviv, Zaporizhzhia, Dnipropetrovsk, Odesa regions and Kyiv. As a result of the calculation, it was determined that the best indicators are observed in Lviv, Zhytomyr regions and the city of Kyiv, which, in turn, determines the choice of these territories as Cluster Centers.

Thus, the trained neural network allows to analyze additional objects of observation that will be loaded into it and can be used (by civil servants, entrepreneurs and other stakeholders) in order to optimally recombine eco-clusters taking into account the institutional environment, innovative enterprises and the labor market. In addition, to determine clustering using the developed neural network approach, it is not necessary to calculate integrated indicators for several years, because the constructed artificial neural network after machine learning is able to identify clusters according to data calculated for one year.

4. Conclusions

- As a result of the research, the need to develop effective methods for the formation and spatial organization of eco-clusters with the involvement of the existing potential of the labor market and the use of existing institutional support was determined. The problem of the formation and implementation of these methods is intensified due to the presence of formal and informal institutions for the development of entrepreneurship, which transform clustering processes and determine the level of socio-economic development of the country's regions and the degree of modernization of regional labor markets.
- The proposed technique of spatial recombination of eco-clusters on the basis of training of neural networks in Statistica Automated Neural Networks

(SANN) taking into account the indicators of regional institutional support, labor market and the activities of innovative enterprises allows to optimize the process of economic and statistical modeling of a large array of data characterizing the basic parameters of the environment in which ecological clusters operate. This neural network approach in combination with the implementation of Prim's Algorithm allows optimizing the process of determining the regions of the country that can become the location of enterprises - Cluster Centers. The practical significance of the trained neural network lies in the possibility of its use by major stakeholders to improve the management of eco-clusters in the context of insufficient institutional support and specific features of existing labor markets in their regions.

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