

WEB-BASED SYSTEM FOR REGIONAL DEVELOPMENT LEVEL EVALUATION

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This article focuses on the automation tools development for evaluating the socio-economic development of Ukraine regions. A model for assessing the level of socio-economic development was developed. This model of determining integral indicators of regional socio-economic development formalizes the calculation procedures and allows developing the method of automated socio-economic monitoring data processing, based on the joint use of factor analysis (principal components method) and expert evaluation. In this work we present a method for automated determination of integral indicators based on factor analysis and expert estimation methods is presented. The method application improved the calculation results reliability and the opportunity provided to analyze the relationships between indicators in terms of their impact on the general regional socio-economic situation. The information-analytical Web-based system for evaluating the socio-economic development of Ukraine regions has been developed and implemented. The Web-based system has three-level architecture of technical tools and intended for processes automation of socio-economic level development evaluating of Ukraine regions based on expert-statistical method. The Web-based application is designed to work with three user groups and provides access to control elements depending on the access level of user.

Keywords: socio-economic development, factor analysis, expert evaluation, integral indicators, Web-based system.

Introduction

A signature feature of the current socio-economic situation is the constant intensive search for ideas, approaches and means to increase the growth rate of regional socio-economic development [1]. Particular attention should be paid to a detailed analysis of administrative decisions, which should primarily be aimed at ensuring stable, balanced development of the region and creating a socio-economic climate conducive to the free accomplishment of market goals and improving the standard of living [1, 2]. Ensuring the stability of regional economic development requires not only effective organizational management, but also constant monitoring of the socio-economic conditions of the region, in order to update administrative decision-making and determine future development prospects. Such research allows to quickly assessing the nature and direction of changes that occur, make administrative decisions adequate to these changes, predict and model the development of the object of analysis. The creation and implementation of systems for assessing socio-economic development makes it possible to more accurately assess the economic situation in the region, monitor and forecast the dynamics and trends of regional financial and economic activities make comparisons and systematic analysis of available indicators

The direct role of information technology in the management system of regional development is determined by the sum total of actions and measures for administrative decisions based on procedures and mechanisms for collecting, accumulating, processing and analyzing socio-economic data using computer technology [3, 4]. Analysis of the specifics of regional socio-economic development is associated with the processing of large data sets, which leads to certain delays in obtaining the results of such analysis, and as a result, erroneous strategies of regional socio-economic development based on certain outdated indicators and conclusions. This may lead to ineffective regional policies and, as a consequence, economic downturns, which in turn can be a catalyst for social upheaval. Thus, there is a need to develop modern methods, models and information technologies for processing socio-economic data, in order to ensure efficient and effective management of regional development

Results and discussion

In the majority of cases, data processing in socio-economic research is carried out on the basis of statistical methods, the main disadvantage of which is the reliability of the conclusions [5, 6]. The importance of specific socio-economic indicators is not taken into account in statistical calculations [7]. This problem is addressed by expert evaluation, where knowledge and experience of experts allow to rank indicators in terms of their importance to ensure the effective functioning of a socio-economic system [8, 9]. Yet, at the same time, expert evaluation does not allow to determine the connections between socio-economic indicators, which can be successfully accomplished through factor analysis [10]. Given the aforementioned circumstances, there was a need to develop a mathematical model based on a statistical method that would take into account the experience and knowledge of the experts on the subject matter.

The expert-statistical method proves to be the most suitable for this case as accounting for knowledge and experience of the experts in your calculations substantially increases reliability of the conclusions received through the research and at the same time, application of the factor model allows to carry out the comprehensive socio-economic analysis by determining the connections between the indicators and assessing the impact of changes in a particular indicator or indicators on the state of the socio-economic system. In this regard, a model for assessing the level of socio-economic development (Fig. 1) was developed based on the joint use of methods of factor analysis (principal components method) and expert evaluation [8, 10-12], which became the basis of the Web-based analytical data system

for assessing the level of regional socio-economic development of Ukraine. In the presented model, the increase of its reliability is achieved by introducing the procedure of expert evaluation into the process of determining the weights of factors [13].

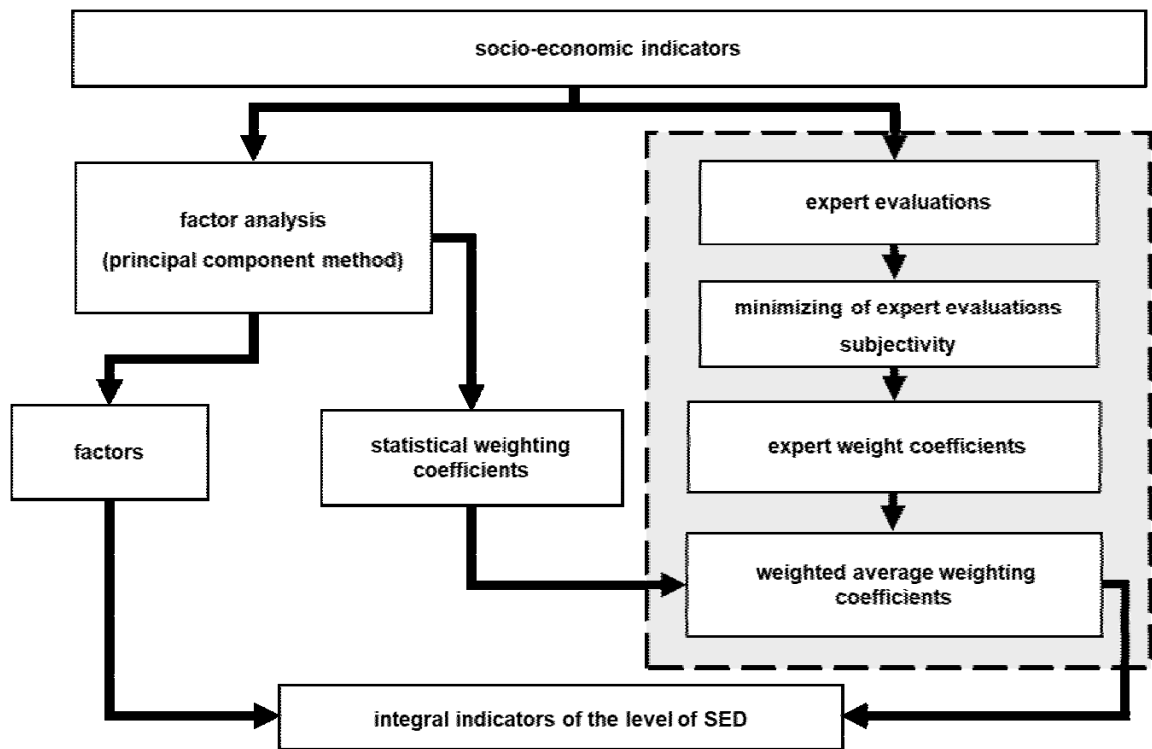


Fig. 1. Model for assessing the level of socio-economic development (SED)

Thus, taking into account the knowledge and experience of experts in determining the weights of factors in the factor model for assessing the level of socio-economic development [10] introduces the importance of specific indicators or, in other words, the intensity of their impact on the socio-economic system. In essence, the weight of the factor determines the degree of its influence in the overall assessment of the development level of the socio-economic system, and taking expert knowledge into account while determining the weights of factors through scoring increases the reliability of the procedure for assessing the state of a socio-economic system. That is, in this model, the integrated indicator of socio-economic development is calculated as the sum of factors with the corresponding average weights.

The model of determining integral indicators of regional socio-economic development formalizes the calculation procedures and allows developing the method of automated socio-economic monitoring data processing, based on the joint use of factor analysis (principal components method) and expert evaluation [13]. The scheme (Fig. 2) shows the algorithm for implementing the method of determining the integral indicator of regional socio-economic development, which allows its program implementation in the form of analytical data system.

The initial stage of the algorithm (that presented in figure 2) is characterized by the introduction of data from socio-economic monitoring of the level of regional development. Such initial data can come from State Statistics Committee of Ukraine or statistical reference books, or, for example, current data from departments of social and economic development of regional administrations. The selected list of indicators determines the direction and objectives of monitoring. Further actions within the presented algorithm are related to the software implementation of the principal components method [11, 12] and expert evaluation mechanisms [8]. According to the principal components method, first a matrix of indicators of socio-economic development of the studied regions is formed, followed by its reduction to a single target function, so that the increase of any indicator corresponds to the improvement of the level of socio-economic condition of region.

Then, the indicators are reduced to the normal distribution law and the pairwise correlation matrix is calculated. Eigenvalues and eigenvectors are calculated for this matrix. The following steps involve multiplying the normalized matrix of indicators and the matrix of eigenvectors, resulting in a matrix of factors. Factors are normalized, their variance is defined and can be used for the integral indicator analysis. The number of N factors included in the integrated indicators is determined based on the eigenvalues of the matrix of pairwise correlations of indicators and a given limit value of the variance of normalized indicators explained by the factors.

basis of the median method and the method of arithmetic means, taking into account the competence of experts, a point evaluation of indicators is calculated. Then expert opinion determines the weight of indicators.

The final step of the algorithm is the calculation of integrated indicators and visualization of data processing results. The weights for each factor are calculated by a combination of expert and statistical estimates. In this case, the generalized weight of a particular factor w (expert-statistical), which takes into account both the opinion of the expert q and a statistical estimate of this factor z , is obtained by calculating the weighted average of these two estimates. To directly determine the integral indicators, it is necessary to combine the estimated factors into a single indicator. Since all factors are independent, they are combined using normal linear convolution [13].

The obtained integral indicators can be used, for example, to identify latent features, compare and rank objects or identify characteristics that determine the socio-economic development (regression) of individual regions, etc. An important point of this method of processing socio-economic data is the automated calculation of the weights of factors based on expert evaluation. The presented construction method of integral indicators allows to implement a unified approach to data analysis and to ensure the efficient construction of integral indicators.

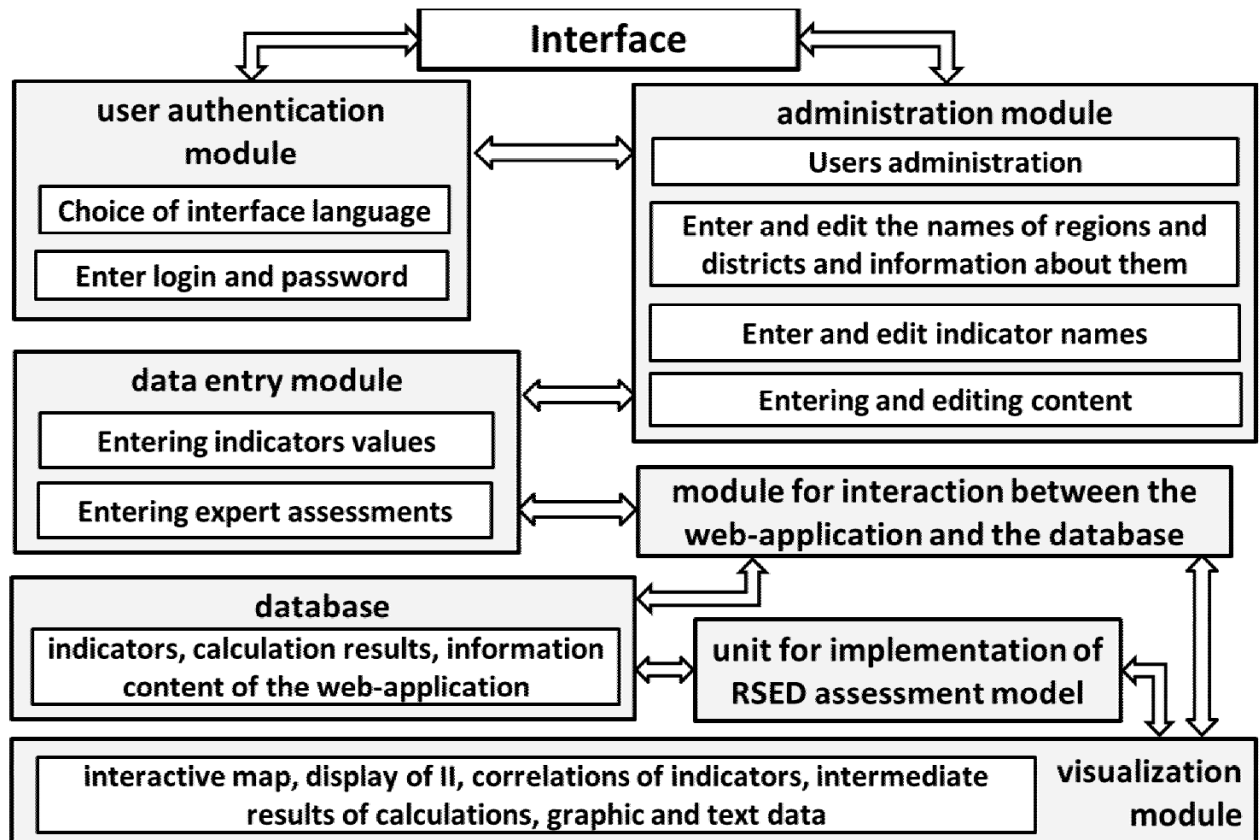


Fig. 3. Logical data model of the Web-based analytical data system for assessing the level of regional socio-economic development (RSED) of Ukraine

The basis and the first stage of creating any information system is development of its logical data model. The conducted research allowed us to determine the connections, structural organization of the functional components of the analytical data system for socio-economic monitoring and the information flow directions to solve its problems. The scheme of the logical data model created for the Web-based analytical data system for assessing the level of socio-economic development is presented in Fig. 3.

The developed logical data model of the Web-based analytical data system for assessing the level of socio-economic development allowed to determine the optimal structural organization of its components and connections between them to ensure effective solution of problems of processing and analyzing socio-economic data and move to software implementation of the Web-based system.

Software implementation of the Web-based system for assessing the level of regional socio-economic development is based on the model [13], which is established through the joint use of factor analysis methods (principal components method) and the method of expert evaluation, according to the proposed method of automated indicators of socio-economic development (Fig. 2). A signature feature of the presented method of calculating integral indicators of socio-economic development is the automation of the expert evaluation mechanism. This method is the basis of the Web-based application, designed to provide access to the functions of assessing the level of socio-economic

development and implementation in the system of regional government. Important aspects of the developed the Web-based system are automation of all calculation procedures and the ability to operate online, which provides access to all Internet resources to remotely situated users. It is also worth noting that the interface of the Web-based application is implemented in two versions: Ukrainian and English. The developed the Web-based application consists of the following functional blocks:

- user authentication module;
- database designed to store indicators and results of calculations of the subject area, as well as data contents of some elements of the Web-based application interface;
- block that implements the functions of the mathematical model of the subject area;
- gateway to ensure coordination between the Web-based application and the database;
- interface that provides access to the functions of the Web-based application.

The Web-based system is designed for three groups of users (administrators, data editors and regular users) and provides access to controls depending on the access level of a particular user. *Regular users* have access to intermediate results and results of calculations of integral indicators, as well as access to information on which indicators were used in the calculations. In addition to the rights of regular users, *data editors* have the ability to add and edit regional socio-economic indicators, perform calculations of integral indicators and store data in the database. *Administrators*, in addition to the aforementioned capabilities, have access to the functions of editing the content of the Web-based application and can register the users of the system with the assignment of appropriate access rights.

The Web-based application is implemented using the pattern MVVM (Model-View-View-Model) [14]. The following tools for software implementation of the Web-based application were selected: DBMS - MySQL [15, 16] and the software part - Microsoft Silverlight 5.0. Silverlight is a software platform that includes a browser plug-in that allows you to activate applications that contain animation, vector graphics, audio and video clips that are typical of RIA (web applications with the functionality of traditional desktop applications), while using a powerful software platform *.NET Framework [17, 18]. Silverlight-based web applications are high-performance, cross-browser applications that use the powerful tools of modern *.NET programming language [18-20]. In our case, the C # programming language [21] is used as the software implementation language of the Web application.

The gateway for communication with the database is a php-interface that provides the generation of queries to the database and the query results [22, 23]. Communication between the Web-based application and php-gateway is based on the http-protocol. Based on the GET method parameters of the http-protocol, the corresponding queries to the database are generated [23]. The resulting samples are serialized in the format *.JSON and transferred to the Web-based application [16, 22]. If you need to store data in the database, the Web-based application generates an object in the *.JSON format, in the php-gateway the object generated by the POST http-protocol is deserialized, and appropriate queries to the database are generated (REPLACE or UPDATE) [23].

Ensuring the functioning of the Web-based application on the server side requires the following: Apache 2.3 and above [24] or MS IIS 7.0 and above [25]; PHP 7.2 and above [26]; MySQL 7.1 and above [15, 16]. The client machine requires a Microsoft Silverlight browser plug-in, the installation of which must be confirmed the first time you access the Web-based application server.

Access to the functions of the Web-based system for assessing the level of socio-economic development requires going through the authentication procedure and selecting the dialogue language (you can work with the Web-based application using Ukrainian and English interfaces) (Fig. 4). After successful authentication, depending on the level of user access to system resources, the program window opens with the appropriate access to the controls of the Web-based application. The selection of the region of Ukraine is carried out with the help of an interactive map. This application uses an interactive graphic image of the regions of Ukraine (interactive map). This means that graphic images of the regions of Ukraine are also a part of controls. This fact is a signature feature of using the application.

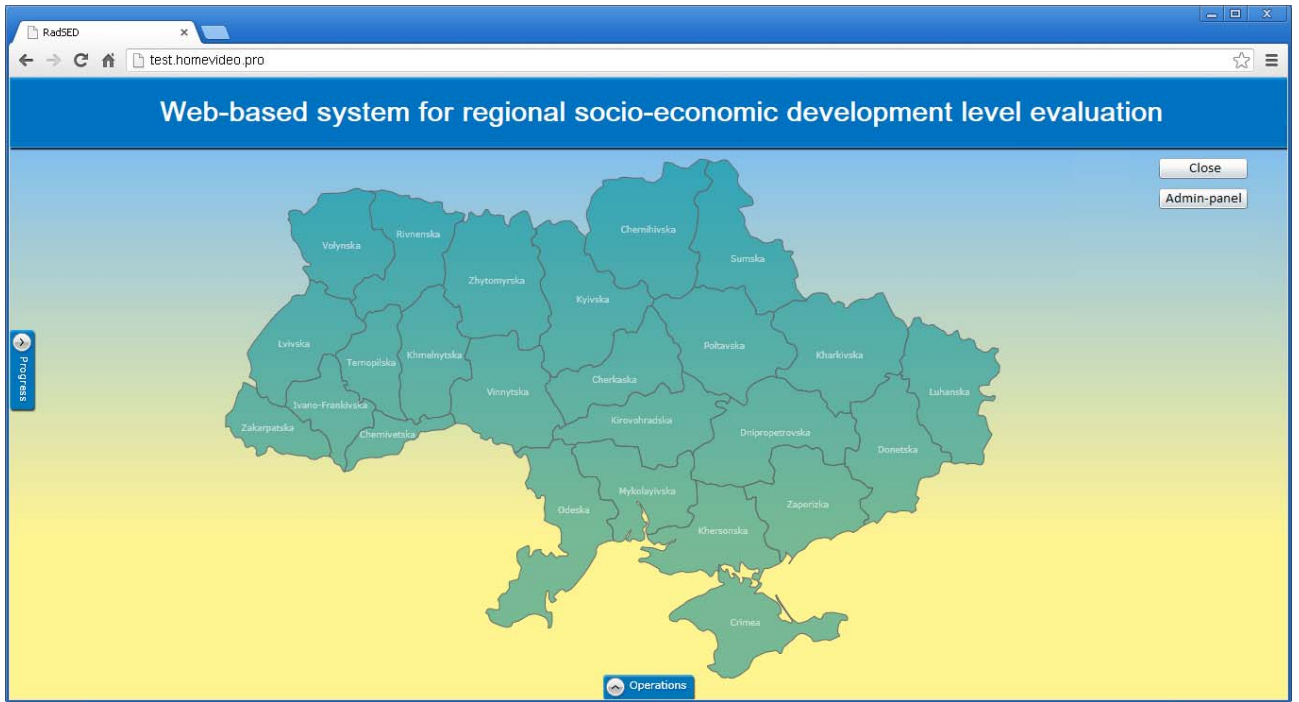


Fig. 4. Main window of the Web-based application for assessing the level of regional socio-economic development of Ukraine

Selecting any region of Ukraine in the dialog box of the application (Fig. 4) automatically links all further operations to this region. Data input to the Web-based system for assessing the level of socio-economic development is carried out in the admin panel of the application. To enter and edit the socio-economic development indicators (P_n) used in the calculations you need to activate the "Calculations" module in the dialog box of the application (Fig. 5).

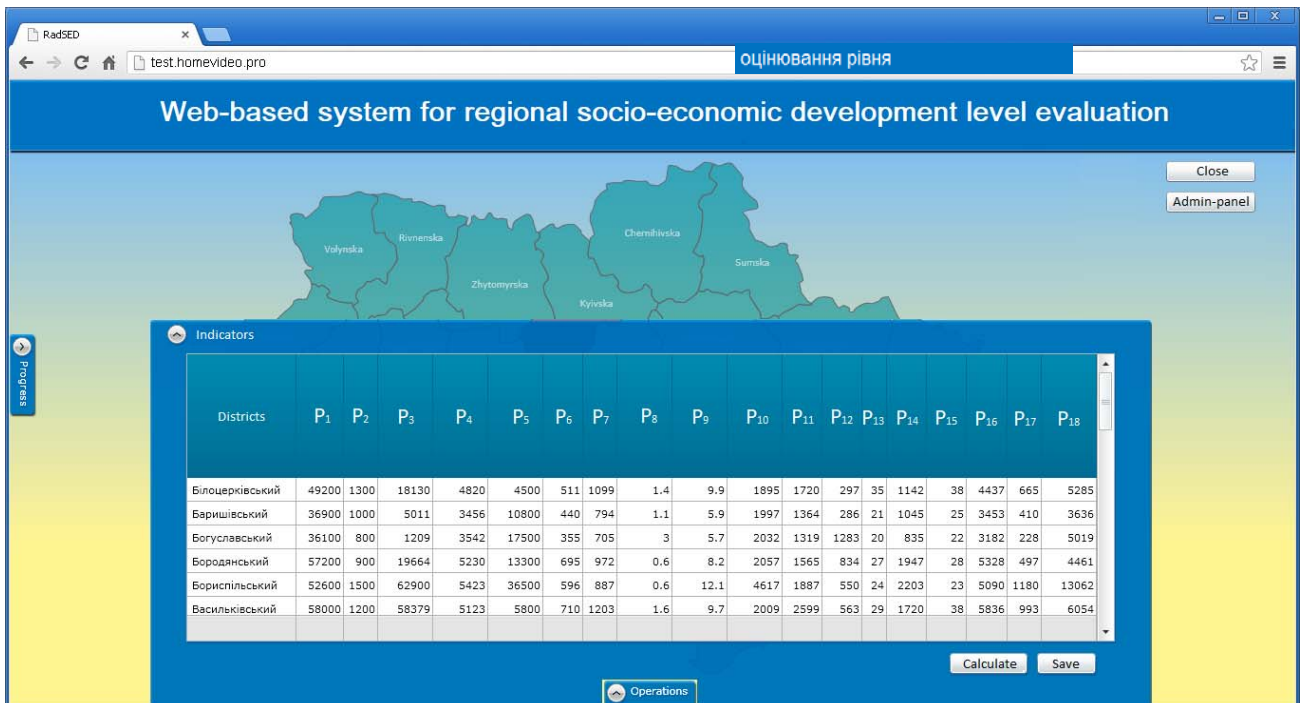


Fig. 5. Web-based application window for activating the «Calculations» menu

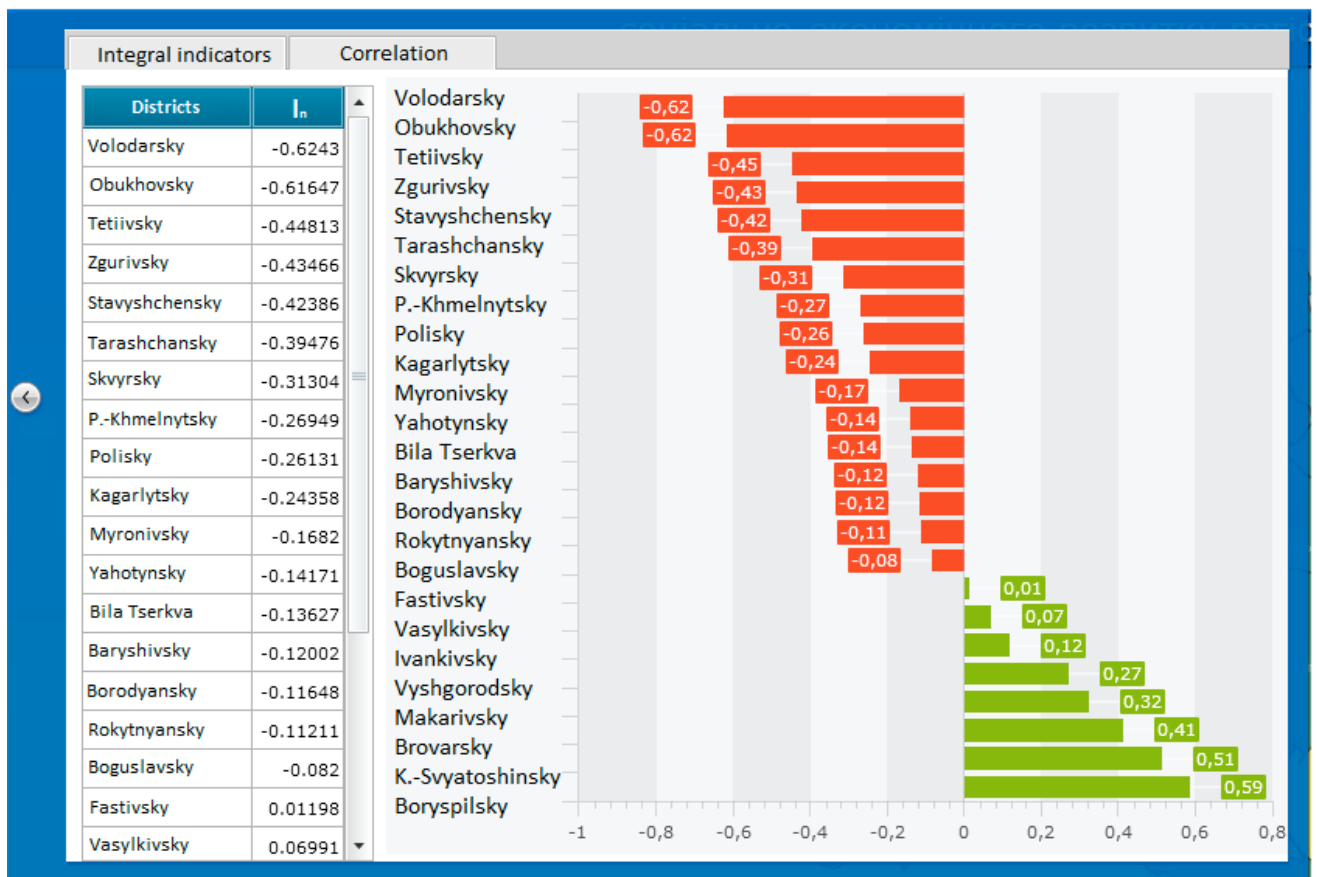


Fig. 6. Integral socio-economic development indicators calculated for Kyiv region districts

To activate the calculation procedure, after entering and saving the indicators in the table, click «Calculations». Then an additional menu item «Intermediate results» appears in the «Calculations» module (Fig. 5). In the menu «Intermediate results» you can activate: the matrix of indicators; normalized matrix of pairwise correlations of indicators; eigenvector matrix and eigenvalues of the matrix of pairwise correlations of indicators; matrix of factors; variance of factors; matrix of correlations between indicators and factors; the weights of factors obtained by expert evaluation. The ability to review the intermediate results of the calculation allows for a more in-depth analysis of socio-economic processes in the region, as well as to determine the most important areas of regional development. Review of the calculations results of integral socio-economic development indicators (Fig. 6) is performed using the module «Results» (Fig. 5).

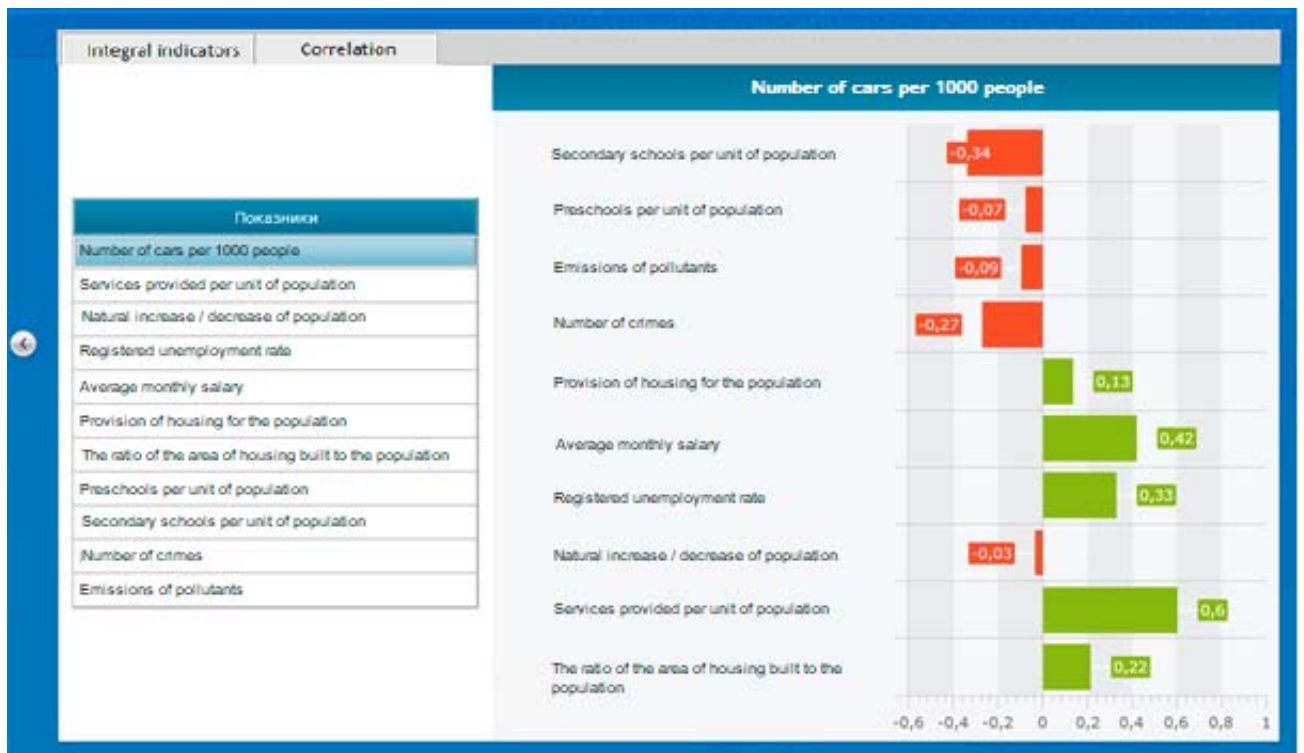


Fig. 7. Diagram of the correlation between socio-economic development indicators

The module contains two tabs - integral indicators (Fig. 6) and correlation of indicators (Fig. 7). Diagrams make it convenient to analyze the impact of changes in one indicator on others and the general socio-economic situation in the region, to establish the causes of positive and negative trends in regional development, to determine the most important socio-economic indicators that require higher level of focus as bases for regional development strategies.

It is worth noting that all the functions listed are available in full only in the administrator mode. For other user groups, the list of these functions is limited. The following is a distribution of control functions for different user groups.

Basic functions, available to the «*Regular users*» group:

- selecting the region, obtaining background information about the selected region;
- reviewing of data on the region - the table «Indicators» presents socio-economic monitoring data for the selected region;
- revision of integral indicators and correlation matrix - in the «Results» module the calculated data of integral indicators and matrix of pairwise correlations for the normalized matrix of indicators with the corresponding diagrams are presented. On the «Correlation of indicators» tab, when selecting an entry in the table, a diagram of mutual indicator correlations is built.

Extended functions, available to the «*Data editors*» group:

- editing data by region. The table "Indicators" includes data from socio-economic monitoring. Clicking on the «Save» button allows you to save the data entered to the database;
- starting calculations of integral indicators. The «Calculate» button launches the process of calculating integral indicators for the selected region of Ukraine, as well as saving the results of calculations in the database;
- The section «Intermediate results» contains available for viewing data tables and arrays: matrix of indicators, normalized matrix of indicators, matrix of pairwise correlations for normalized matrix of indicators, table of eigenvectors and numbers for matrix of pairwise correlations of indicators, factor matrix, factor variance, matrix of correlations between factors and indicators.

All additional functions, available to the «*Administrators*» group:

- editing the registration data of system users. In the section «Editing users» the administrator of the Web-based application has the ability to add users, edit user data and save the information entered to the database. The obligatory field for filling in the table "Users" is «E-mail», which must be unique within the system. «Password» can be generated automatically when adding a user to the system;
- editing the contents of the Web-based application. All contents of the Web-based applications available in two languages: Ukrainian and English. Adding and editing names and descriptions in the section «Editing areas and districts» provides two tables. In the section «Editing names of indicators» the

corresponding table in which it is possible to change names of indicators and their units of measurement is available. Access to the «Edit Content» section allows to change the content of the main page.

Conclusion

To summarize, the Web-based system for assessing the level of regional socio-economic development of Ukraine, developed and implemented using modern software and on the basis of expert-statistical method, is easy to use, has an intuitive interface, provides interactive dialogue of the system user in the process of operating the system, distributes levels of user access, does not require specialized user training and significant expenses for its implementation in the system of regional governance and can be easily modified depending on the direction and objectives of socio-economic monitoring. Based on its use, it is convenient to analyze the level of regional socio-economic development, determine the dynamics of changes in integral indicators, identify the causes of positive and negative trends in regional development, determine the list of most important socio-economic indicators that require higher level of focus as bases for regional development strategies.

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