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INNOVATION AND INVESTMENT POTENTIAL OF REGION AS A FACTOR OF ITS "SMART TRANSFORMATION" – A CASE STUDY OF KHARKIV REGION (UKRAINE)

Л. М. Нємець, К. В. Мезенцев, К. Ю. Сегіда, Ч. Морар, Н. В. Гусєва, В. А. Пересадько, Є. Ю. Телебєнєва. ІННОВАЦІЙНО-ІНВЕСТИЦІЙНИЙ ПОТЕНЦІАЛ РЕГІОНУ ЯК ФАКТОР ЙОГО «SMART-ТРАНСФОРМАЦІЇ» – КЕЙС ХАРКІВСЬКОЇ ОБЛАСТІ УКРАЇНИ. *У роботі розглядається позиціонування Харківської області і міста Харкова як «розумного (smart) регіону». Наведено стратегічні та операційні цілі їх розвитку в аспекті формування «розумної (smart) економіки». Проаналізовано інноваційно-інвестиційний потенціал Харківської області як фактор її smart трансформації; виявлено особливості його формування та використання в аспекті розвитку Харківської області як «розумного (smart) регіону». За допомогою математико-статистичного аналізу визначено місце Харківської області в національному вимірі за окремими показниками інноваційної та інвестиційної діяльності та в цілому за інноваційно-інвестиційним потенціалом. Зокрема зазначено, що Харківська область займає 2 місце в Україні за інтегральним показником формування і використання інноваційно-інвестиційного потенціалу, поступаючись тільки Києву. За результатами факторного аналізу обгрунтовано фактори формування та використання інноваційно-інвестиційного потенціалу Харківської області (соціально-економічний, розселенький, житлово-торгівельний та соціально-демографічний), їх зміст (факторні навантаження) та внутрішньорегіональні особливості впливу (факторні ваги). Використовуючи кластерний аналіз (метод Варда, евклідова відстань), було проведено групування міст і районів Харківської області за подібністю їх інноваційно-інвестиційної діяльності (було виділено 4 групи міст та 5 груп районів). Результати кластерного аналізу дозволили зробити висновок, що Харківська область характеризується значною територіальною диференціацією особливостей формування й використання інноваційно-інвестиційного потенціалу її адміністративно-територіальних одиниць, що в першу чергу пов'язано зі специфікою їх соціально-економічного розвитку. Безперечними лідерами є місто Харків та Харківський і Дергачівський райони, які характеризуються найвищою інвестиційною привабливістю та інноваційною активністю, і в цілому – найбільшим інноваційно-інвестиційним потенціалом. Виявлені особливості територіального розподілу інноваційно-інвестиційного потенціалу регіону дозволили виявити проблеми та окреслити перспективи подальшого використання наявних його ресурсів.*

***Ключові слова**: розумна (smart) економіка, розумна (smart) трансформація, інноваційно-інвестиційний потенціал, Харків, Україна.*

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Ключевые слова*: умная (smart) экономика, умная (smart) трансформация, инновационно-инвестиционный потенциал, Харьков, Украина.*

Formulation of the problem. Recently, Kharkiv region was increasingly positioned as a "smart region" and Kharkiv as a "smart city", defined as a modern, social city, a city of arts, research, tourist city (SMART = Social, Modern, Art, Research, Tourism) (*Zhavzharova, 2016*). Moreover, the emergence of "smart economy" and the availability of people with jobs is one of the six strategic objectives for the city development by 2020, which includes three operational objectives: 1) innovative active entrepreneurial city (Kharkiv is Ukraine's leading innovation center, Kharkiv – active entrepreneurial city); 2) information – creative city (Kharkiv is a leading information technology center in Ukraine, Kharkiv – a tourist center of Eastern Europe, Kharkiv is a creative center of the European level); 3) Scientific and educational city of knowledge-based economy (*Development strategies…, 2016*).

Thus, the formation of Kharkiv region as an "intelligent region" with "smart economy" implies, among other objectives, a comprehensive development of innovation and investment activities in the region, its transformation into Ukraine's leading innovation and investment center. A mandatory condition of the region's progressive socio-economic development is the economy of innovation type, which is impossible without investment. In economics intellectual products (innovation developments) as scientific results of human activities are of primary importance. Innovation is a significant precondition for economic development of both economic systems of individual regions, and the country as a whole (*Fedotova, 2015*).

Among the factors of "smart (intelligent) economic" development are innovations, science and education, IT-technologies, intellectual potential, etc. Not least in the importance is investment in human capital, growth of highly technological section in the social production sphere, the added value increase in the composition of output created by intellectual component. The changing nature of human labor in favor of creative and intellectual activities is also a factor of such an economy where innovation and investment activities are the priority areas (*Development strategy …, 2016*).

The regions characterized by the existence of innovative economic structures and activities benefit from the existence of the appropriate regional development policies, that support and stimulate the economic growth based on innovation, rather than assist the regions in decline (e.g. the old industrial regions) (*Benedek, 2004; Cocean, 2005*). A new perspective explains that the innovative regions through the different propulsive industries support a complex regional system, considering also the delay of the regional innovation comparing with the historic expansion of industry from a specific area (*Quatraro, 2009*). Creativity is the main driving force in regional economic growth, concentrated especially in situations where the society generates and applies new ideas, information and technology (*Strom, Nelson, 2010*). The new regionalism rhetoric supports the idea that the regions have to be coupled strategically with the global economy through critical links (*Yeung, 2009*). The measures aimed at growing and diversifying economic activities, stimulating the investment in the private and public sector, contributing to reducing unemployment and leading to an improvement of overall living standards, support sustainable actions that converge with the areas of competence of regions, generate a dynamic and sustainable growth based also on the decentralization of the decision-making process (from the central or governmental

level to the regional communities) and on the partnership between all actors involved in the overall regional development process (*Benedek, 2004*).

Analysis of previous research. R. G. Hollands in the article «Will the real smart city please stand up? Intelligent, progressive or entrepreneurial?» (*Hollands, 2008*) focuses on the difficulties of smart cities definition. The author emphasizes that smart cities should be non-formal entities, namely, those that improve the lives of their inhabitants. Despite a detailed analysis of some key concepts and concrete cases of smart cities, the author underestimates cities in the development at the regional and national levels.

Also, a number of authors, such as R. Krueger, D. Gibbs (««Third wave» sustainability? smart growth and regional development in the USA»), A. Kylili, P. A. Fokaides («European smart cities: The role of zero energy buildings») examine specific examples of some regions of smart cities, including the western coast of the United States and Europe (*Krueger, Gibbs, 2008; Kylili, Fokaides, 2015).* The main message of these studies is their focus on highlighting positive changes in regions where smart cities are formed. However, there are no criticisms or suggestions for the development of other cities in the context of the concept of smart cities.

We can say that the city itself is the main center for the birth and spread of investments. It is in this context that P. Benneworth and G.J. Hospers in the article «The new economic geography of old industrial regions: universities as global/local pipelines» (*Benneworth, Hospers, 2007*) argue that the university of major cities should be one of the main sources of innovation in the regions. This actually confirms the educational component in the concept of smart cities.

A. Rodríguez-Pose and R. Crescenzi in the article «R&D, spillovers, innovation systems, and the genesis of regional growth in Europe», generate the idea of distributing innovations in the region, precisely because of the spread of knowledge. Following the three approaches: "linear model" of innovation; regional innovation systems; and the dissemination of knowledge, the authors confirm their own theory. They just do not take into account the fact that only one or two cities in the region have an innovative potential, therefore, the development of measures for the harmonious development of the region is important. (*Rodríguez-Pose, Andrés and Crescenzi, Riccardo, 2008*).

In our opinion, J. Kaivo-Oja, S. Vähäsantanen, A. Karppinen, T. Haukioja's research on the development of regions and the current conditions for the establishment of greenwich cities and the spread of innovation has been conducted as deep as possible, the results of which are described in the article «Smart specialization strategy and its operationalization in the regional policy: case Finland». Smart cities are only part of the intelligent development of the regions. Sustainable development of the region is, above all, smart development. In this paper, a set of methods is given to determine the level of the territory development in this context. Unfortunately, there are not enough comparative studies, but this provides an opportunity for further research (*Kaivo-Oja, Vähäsantanen, Karppinen, Haukioja, 2017*).

Materials and methods. This paper is based on quantitative research approach aimed at statistical assessment of the key factors and features of the innovation and investment potential of the region. For this purpose we used multivariate methods of factor and cluster analysis. Using the first one, we identified and interpreted determinants of innovation and investment potential of the region as a whole and their manifestation in different territorial units. Cluster analysis (Ward's method) allowed to group territorial units by similarity of nine determined indicators which express different aspects of the capital investments and innovation-active enterprises.

Kharkiv region is taken as a case study in order to explain the main drivers and spatial patterns of the innovation and investment potential of the monocentric industrial region in post-Soviet space. Kharkiv is the second most populous city in the country, which for some time (from 1919 to 1934) served as the capital of Soviet Ukraine. Kharkiv is the center of metropolitan region that in whole or partly covers Kharkiv, Sumy, Poltava and Luhansk administrative regions. In informational space Kharkiv is positioned as a regional capital of the North-East Ukraine. The regional capital is usually far ahead in the region by the most of key socio-economic indicators, the center of gravity of population and capital. However, during the period from 1989 to 2014 Kharkiv's population decreased by nearly 10 %. In terms of capital investment and services sold per capita Kharkiv is the leading center.

The empirical part of the paper is based on official statistics from the Main Department of Statistics in the Kharkiv region, in particular Statistical Yearbook "Cities and districts of Kharkiv region in 2015" and "Kharkiv region in 2015".

In order to display the innovation and investment potential of Kharkiv region as a factor of its "smart transformation", to identify the features of its formation and use in terms of Kharkiv region's "smart transformation" priorities, the paper is organized in the following way. In the first part we determine the role of innovation and investment potential of Kharkiv region at the national scale. The next section is devoted to identification of the factors of innovation and investment potential formation. In the following section we attempt to explain the spatial pattern of the investment and inovation activity in the

Kharkiv region. The paper ends with some conclusions that emerge from the analysis.

Results and discussion. ***Innovation and investment potential of Kharkiv region at the national scale.*** From the standpoint of social geography *innovation and investment potential* of the region can be defined as the opportunities of regional socio-economic system to conduct innovative activity based on the resource component formed by scientific, intellectual, human, financial, technical and technological resources. The formation of the region's investment potential is ensured by innovation development and achievement of competitive advantages in the region. Kharkiv region is characterized by all these components.

Kharkiv region occupies one of the leading places in Ukraine in terms of innovation and investment activity. Thus, regional differences in 19 indicators of investment and 19 indicators of innovation in 2015 have been analyzed. The analysis showed that:

- in 2015 Kharkiv region was the leader in the country *by three indicators* (the number of companies that have sold innovative products abroad, in units; the number of industrial enterprises that implemented innovations, in units; the number of implemented new technological processes at the industrial enterprises, in units);
- *by five indicators* (utilized capital investments from the state budget, UAH and share of the total volume; utilized capital investments at the expense of local budgets, share of the total volume; the number of patents for inventions (national applicants, without non-classified), in units; sales of innovative products from Ukraine, UAH) – *obtaine the 2nd place in the country*;
- *by six indicators* (utilized capital investments at the expense of local budgets, UAH; number of industrial enterprises engaged in innovative activities, in units; number of industrial companies that have sold innovative products, in units; the volume of innovation products sold, UAH; number of acquired new technologies (technical achievements) in Ukraine and abroad, in units; the number of transferred new technologies (technical achievements) in Ukraine and abroad, in units) – *3rd place in the country;*
- *by one indicator* (total expenditure on innovation activity, UAH) – *4th place in the country;*
- *by seven indicators* (direct foreign investments, USD and share of the total volume; utilized capital investments, UAH and share of the total volume; number of implemented technological processes items per industrial company that implemented innovations, units per company; number of introduced innovative products at industrial enterprises, in units; the volume of utilized innovation products per industrial company that implemented innovative products, USD per company) – *5th place in the country;*
- *by six indicators– 6th place in the country;*
- *by two indicators – 8th place in the country;*
- *by two indicators – 10th place in the country*;
- *by one indicator – 12th place in the country*;
- by *one indicator – 13th- place in the country*;
- *by two indicators – 14th place in the country;*
- *by one indicator – 15th place in the country*;
- *by one indicator – 16th place in the country*.

To determine the role of Kharkiv region by all indicators of innovation and investment activities we have ranked all regions of Ukraine by selected statistical indicators (19 indicators of investment and 19 indicators of innovation activity). This process involved the following steps:

1. Rationing of simple indicators, bringing them to a common denominator.

2. Linear scaling of normalized parameters, i.e. parameters transformation so that their numerical values – indexes were in the range of 0-1. To do this, extreme (lowest and highest) values were determined by each indicator by the formula (*Niemets et al., 2009*):

$$I_j = \frac{X_{i,j} - X_{min,j}}{X_{max,j} - X_{min,j}} \qquad (1)$$

where I_j – normalized variable, j = 1, 2, 3 .... N (N – number of variables in the sample; in this case N = 38); $X_{i,j}$ – the current value of the j-normalized variable, i = 1, 2, 3 ... M (M – number of objects characterized by j-indicator; in this case M = 25); $X_{min,\ j}$, $X_{max,\ j}$ – the smallest and largest value of j- indicator in the number of observations.

According to (1), the object with the largest value of a certain indicator has index equal to 1, and the lowest – 0, the indices of all other objects have numeric values in the range of 0-1. Average indices of innovation and investment activity in the regions of Ukraine were calculated by formula (2) (*Niemets et al., 2009*):

$$I_{aver} = \frac{\sum_{j=1}^{N} I_j}{N} \qquad (2)$$

All designations are as above.

3. Ranking of regions in Ukraine in terms of their innovation and investment activity in descending order of average index. As a result, we received the order in which the place (rating) of a region as to the development of innovation and investment activity clearly defines its position among other regions. This procedure is done graphically on the Pareto charts (*Niemets et al., 2009*):

Thus, it is clear from *Figure 1* that Kharkiv region occupies the second place in Ukraine as to the integral index of formation and use of innovation and investment potential, conceding only the city of Kyiv.

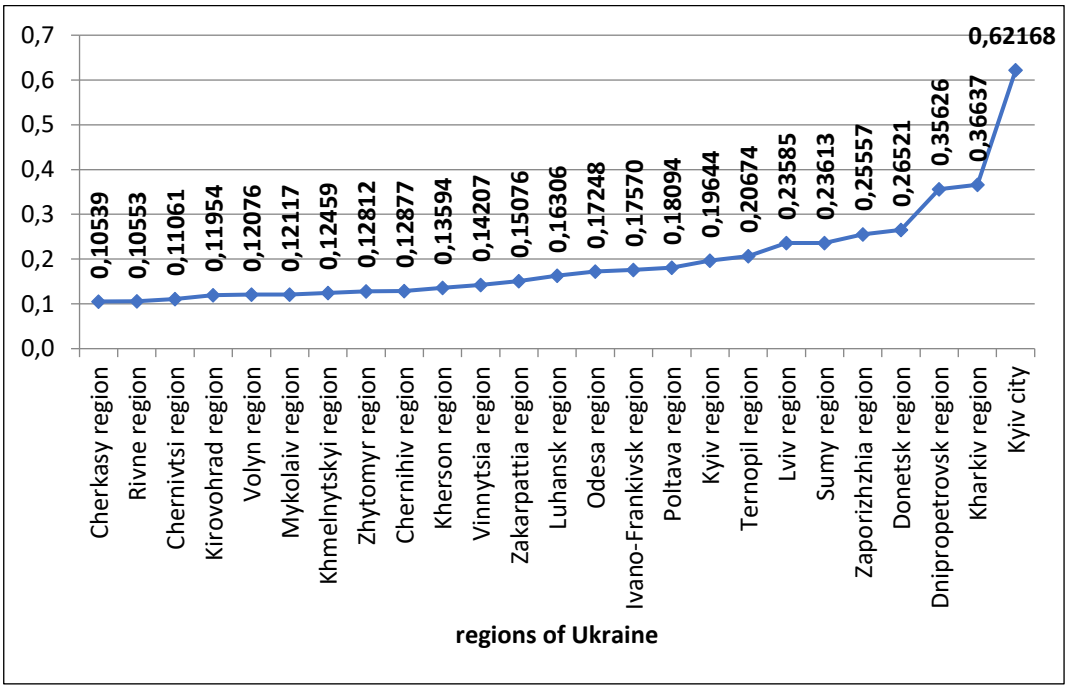

Fig. 1. Pareto chart showing distribution of the regions of Ukraine as to the average index of innovation and investment activity in 2015. (Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*; without temporarily occupied AR Crimea and the city of Sevastopol)

Factors of innovation and investment potential formation and use in Kharkiv region. The authors have analyzed the factors affecting the formation and use of innovation and investment potential of Kharkiv region based on the principal components method of varymax factor rotation (*Niemets, Sehida, 2017*). This allowed us to calculate the factor load on each of the indicators. Considering available accessible statistical information for the study, we selected 87 indicators, reflecting the demographic, economic, social and environmental characteristics of the administrative units in Kharkiv region in 2015. They were linearly scaled, too. Equation (1) is used to calculate the indicators of positive qualities or objects' characteristics. For indicators of negative trends and the objects' characteristics (such as mortality, the number of immigrants, pollutants emissions into the atmosphere from stationary sources, the number of victims of production accidents, etc.), the indexes are determined by the following formula (*Niemets et al., 2009*):

$$I_j = 1 - \frac{X_{i,j} - X_{min,j}}{X_{max,j} - X_{min,j}} \qquad (3)$$

Using inverse index values for "negative" indicators by formula (3), it is possible to correctly rank administrative units in the region according to all sample indicators of their innovation and investment potential. In other words, the administrative unit with higher "positive" and lower "negative" indicators of innovation and investment potential has higher priority ranking (*Niemets et al., 2009*).

The first step of the factor analysis assumes that the number of factors is equal to the number of indicators. We calculated the variance of each factor to determine the optimum number of factors (*Table 1*).

The optimal number of factors can be determined using three criteria:

- the Kaiser's rule (*Kaiser, 1960; Horn, 1965*): only factors with eigenvalue greater than 1 (in our case 10 factors) are selected;

- by a cumulative percentage of variance: the factors that cumulatively cover approximately three-quarters of the initial information are selected as the determining ones, i.e. the cumulative percentage exceeds 75 % (in our case 3 factors);

- the Cattell's scree test (*Cattell, 1966*): on the variances graph (scree plot) there is a place where the variance reduction slows at most from left to right. It is assumed that there is only a "factorial scree" to the right from this point.

- the scree plot (*Figure 2*) shows 3-4 factors.

Thus, we assume that 4 factors have the biggest impact on the formation and use of innovation and investment potential in Kharkiv region.

As a result of varimax raw rotation we obtained a matrix of factor loadings (*Table 2*).

Based on the factor loadings values we have found the content of factors affecting the formation and use of innovation and investment potential in Kharkiv region (it includes the indicator with the largest load, that is closest to the module unit). If the indicator's factor loading is less than 0.7 for each of the 4 factors ("threshold" value), this figure is not

Table 1

Absolute, relative and cumulative values of factors variance in formation and use of innovation and investment potential of Kharkiv region, 2015
(Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

Factor	Variance	Percentage of total variance %	Cumulative variance	Cumulative percentage %
1	51,38861	59,06737	51,38861	59,0674
2	9,12912	10,49324	60,51773	69,5606
3	5,34415	6,14270	65,86188	75,7033
4	3,58838	4,12457	69,45026	79,8279
5	2,71034	3,11533	72,16060	82,9432
6	2,33007	2,67824	74,49067	85,6215
7	1,97916	2,27490	76,46983	87,8964
8	1,65993	1,90797	78,12976	89,8043
9	1,28006	1,47134	79,40982	91,2757
10	1,08531	1,24749	80,49513	92,5231
11	0,98116	1,12777	81,47629	93,6509
12	0,95369	1,09619	82,42998	94,7471
13	0,80606	0,92651	83,23604	95,6736
14	0,63228	0,72676	83,86833	96,4004
15	0,54853	0,63049	84,41685	97,0309
16	0,52826	0,60719	84,94511	97,6381
17	0,41100	0,47241	85,35611	98,1105
18	0,32970	0,37897	85,68581	98,4894
19	0,24490	0,28149	85,93071	98,7709
20	0,22109	0,25412	86,15180	99,0251
21	0,17934	0,20614	86,33113	99,2312
22	0,13684	0,15729	86,46798	99,3885
23	0,11492	0,13209	86,58289	99,5206
24	0,11114	0,12775	86,69404	99,6483
25	0,08198	0,09423	86,77602	99,7426
26	0,06208	0,07135	86,83810	99,8139
27	0,04036	0,04639	86,87846	99,8603
28	0,03791	0,04357	86,91637	99,9039
29	0,02850	0,03276	86,94487	99,9366
30	0,02319	0,02665	86,96806	99,9633
31	0,01432	0,01646	86,98238	99,9797
32	0,01160	0,01333	86,99397	99,9931
33	0,00603	0,00693	87,00000	100,0000

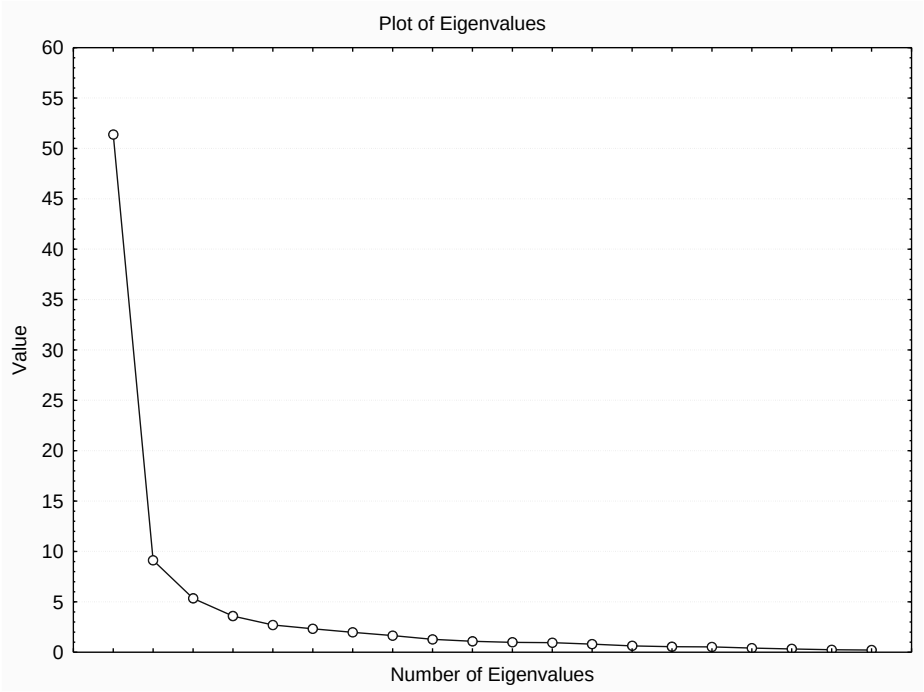

Fig. 2. Scree plot for determing the number of factors of formation and use of innovation and investment potential in Kharkiv region, 2015
(Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

Table 2

Factor loadings (Varimax raw, principal components, marked loadings are >0,7)
(Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

Indicators	**Factor loadings**			
	factor 1	**factor 2**	**factor 3**	**factor 4**
number of EDRPOU subjects, units	0,99551	0,060204	-0,003599	0,052213
number of EDRPOU subjects, units per 1,000 people	0,67855	0,156036	0,207699	-0,251586
number of residents, persons	0,99264	0,052546	0,036952	0,082873
population density, persons per sq km	0,57896	0,544008	-0,083907	0,385574
urban population, persons	0,99157	0,086698	0,008436	0,079167
rural population, persons	-0,13334	-0,693031	0,565982	0,061374
fertility, persons	0,99215	0,049648	0,040742	0,087964
fertility, per 1,000 people	-0,21384	-0,060433	-0,078177	-0,028107
mortality, persons	-0,99079	-0,041197	-0,061307	-0,083125
mortality, per 1,000 people	0,34296	0,168995	0,079378	0,811672
natural increase (decrease) of population, persons	-0,98445	-0,024820	-0,100576	-0,073526
natural increase (decrease) of population, per 1,000 people	0,27774	0,151452	0,054970	0,812517
number of arrivals, persons	0,99115	0,051746	0,041883	0,080218
number of arrivals, per 1,000 people	0,04083	0,001577	0,079996	0,076452
number of departures, persons	-0,99240	-0,058354	0,000164	-0,081945
number of departures, per 1,000 people	0,07150	0,114605	0,300115	-0,022231
net migration, persons	0,93153	0,016054	0,248997	0,067299
net migration, per 1,000 people	0,10150	0,094976	0,329134	0,062964
need of employers for workers to fill vacant jobs (vacant positions), persons	0,99500	0,050386	-0,035804	0,040674
number of registered unemployed, persons	-0,91113	0,239141	0,092283	0,031918
load per one vacancy (vacant position), persons	0,11310	0,426649	0,063702	0,124947

employment of registered unemployed, persons	0,87149	-0,341453	-0,075073	-0,040626
average number of staff, people	0,99376	0,061191	-0,010997	0,073592
average monthly nominal salary of staff, UAH	0,21312	0,051573	0,042555	-0,002110
passenger road transport, mln. pass. km	0,96110	0,022111	0,194298	0,084335
road passenger transport thousand, passengers	0,97265	0,050487	0,149504	0,091892
kindergartens, units	0,99054	-0,037103	0,037206	0,079801
children in kindergartens, persons	0,99229	0,074587	0,002335	0,082532
general education establishments, units	0,98209	-0,112538	0,068380	0,096345
children in secondary schools, persons	0,99216	0,058079	0,032550	0,088067
number of pensioners who receive pension in the Pension Fund, persons	-0,99156	-0,064151	-0,029405	-0,078834
number of disable pensioners who receive pension in the Pension Fund, persons	-0,99000	-0,058806	-0,056203	-0,093825
grants for reimbursement for housing and communal services, UAH	0,95494	0,169490	-0,046566	0,141213
housing, sq m	0,99042	0,047897	0,054105	0,091910
urban housing, sq m	0,98935	0,090650	0,025480	0,090268
provision of housing, the average per capita sq m	-0,28100	-0,105624	-0,062037	-0,429889
housing commissioning, sq m	0,98258	0,029255	0,142865	0,074149
retail trade turnover, including restaurant management, mln. UAH	0,99417	0,075627	-0,026029	0,054739
emissions of pollutants into the atmosphere from stationary sources, tons	-0,88084	0,014664	-0,055901	-0,103251
emissions of pollutants into the atmosphere from stationary sources of pollution per capita, kg	0,05821	0,071307	-0,040661	-0,046045
existence of waste, tons	0,00090	0,068708	-0,051258	0,049997
waste, tons	-0,95824	-0,013562	0,042025	-0,079767
land area, sq km	-0,11036	-0,944815	0,062182	-0,103888
share of urban population, %	0,25634	0,647884	0,177431	0,422301
share of rural population, %	-0,25634	-0,647884	-0,177431	-0,422301
number of towns, units	0,17348	0,145166	0,362719	0,340077
number of settlements, units	-0,04848	-0,249782	0,892795	0,213570
number of villages, units	-0,20860	-0,868149	0,109527	-0,136794
number of female population, persons	0,99268	0,050035	0,038042	0,083416
number of male population, persons	0,99239	0,054157	0,038038	0,083781
men for 1000 women, persons	-0,00894	-0,704546	-0,122110	0,015408
proportion of the population aged 0-14, %	-0,45530	-0,098945	-0,111255	0,100163
proportion of the population aged 15-64, %	0,39612	0,173551	0,192048	0,783713
proportion of the population aged over 65, %	0,19159	0,136283	0,149894	0,900222
population aged 0-14 years, persons	0,99093	0,048159	0,052373	0,093146
population aged 15-64 years, persons	0,99262	0,053910	0,036288	0,083347
population aged over 65 years, persons	-0,99304	-0,047677	-0,034682	-0,077108
number of universities of I-II levels of accreditation, units	0,97925	0,107298	-0,073174	0,075612
number of universities of III-IV levels of accreditation, units	0,99469	0,066989	-0,033248	0,038956
number of victims of industrial accidents, persons	-0,99158	-0,062932	-0,016565	-0,084566
number of deaths from injuries related to production entities, persons	-0,93360	-0,050049	0,038770	-0,049405
number of pensioners who receive pension in the Pension Fund, per 1,000 people	0,07392	-0,157529	0,083628	0,222864
number of disabled people who are registered in the Pension Fund, persons	-0,99128	-0,065568	-0,039179	-0,086071

number of disabled people who are registered in the Pension Fund, per 1,000 people	0,10296	-0,152699	0,022761	0,070104
number of detected crimes, units	-0,99156	-0,078963	-0,009785	-0,082884
transportation of goods by road, tons	0,96571	-0,027013	0,089890	0,053127
freight road transport, mln. tons	0,96343	0,023749	0,212582	0,100529
profitability of agricultural production in the agricultural enterprises (total), %	-0,05243	-0,387412	-0,034978	-0,159349
profitability of agricultural production in the agricultural enterprises (crop), %	-0,04257	-0,371942	0,008823	-0,086593
agricultural land, ha	-0,18976	-0,942850	-0,001100	-0,107629
commissioning of housing per 1,000 people, sq m	0,32685	-0,019260	0,738031	0,144963
number of museums, units	0,77634	0,055049	-0,198485	0,077603
number of clubs, units	0,20093	-0,914768	0,214941	-0,002309
number of library, units	0,73878	-0,597124	0,196386	0,043099
number of movies demonstrators, units	0,35869	-0,153278	-0,136877	-0,005620
children's health and recreation facilities working in summer, units	0,96136	-0,060776	0,114648	0,144544
use of fresh water, mln. m^3	-0,05385	0,240685	-0,044331	0,122450
wastewater discharge, mln. m^3	-0,94912	-0,086303	-0,099600	-0,015144
hotels and similar accommodation, units	0,98257	0,099171	-0,060186	0,087316
specialized accommodation facilities, units	0,21249	-0,179565	0,064124	-0,041035
retail trade turnover per capita, USD	0,70237	0,384451	0,106057	0,357142
wholesale trade turnover, mln. UAH	0,98680	0,054531	0,096383	0,069779
number of enterprises, units	0,99547	0,062153	-0,014030	0,046786
volume of products (goods and services), per capita, USD	0,42070	-0,133125	0,783406	0,129330
volume of products (goods and services), USD	0,98751	0,036375	0,113500	0,070089
income before tax, UAH	-0,98303	-0,106150	0,013372	-0,017585
profitability of operating companies (the ratio of financial result from operating activities to the expenses for operating activities), %	-0,16523	-0,269938	-0,221272	-0,079203
Expl. Var	**49,87322**	**7,354603**	**3,395069**	**4,335184**
Prp. Totl	**0,57326**	**0,084536**	**0,039024**	**0,049830**

included in the analysis because it is statistically negligible. In the analysis of simulation results, it has been found out that 21 of the 87 variables have a load factor lower than the threshold, so they are not taken into account. Given the proportion of variance, we consider the first two factors the most important (1 st factor accounts for 51.4 % of the total variance of the output data, the 2nd – 9.1 %). Interpretation of factor analysis made it possible to identify the following hypothetical factors:

1) social-economic (51 varibales) (*Table 2*);

2) settlement (land area, sq km; number of villages, units; men for 1000 women, persons; agricultural land, ha; number of clubs, units);

3) residential and commercial (number of settlements, units; commissioning of housing per 1,000 people, sq m; volume of products (goods and services), per capita, USD);

4) social-demographic (mortality, per 1,000 people; natural increase (decrease) of population, per 1,000 people; proportion of the population aged 15-64, %; proportion of the population aged over 65, %).

The last line in the table 2 shows the intensity of the factors' influence. Thus, the numerical values of ~ 0.5733 ~ 0.0845 ~ 0.039 ~ 0.0498 correspond to 57.3 %, 8.5 %, 3.9 % and 5.0 % of the total variance.

According to the results of the factor analysis we calculated factor values in the context of towns and districts of Kharkiv region, i.e. the factor scores (*Table 3*). A factor scores help clarify the nature of the factors (*Grice, 2001*), it's a measure of administrative territorial units' contribution in the region to each factor. The matrix of factor scores is calculated by multiplying the output data matrix by a matrix of factor loadings. They are treated as relative evaluation of certain factors expression in each administrative-territorial unit and serve as the basis for their grouping. If the factor score is around 0, the impact of this factor corresponds to the impact for the whole region, if it is higher (especially more than 1) - the impact of this

factor is significantly larger, and if it is lower (less than 1), it is significantly smaller than in the region on the whole.

Figures 3-6 show the Pareto charts for each of the identified key factors. The value of operating factors is significantly differentiated in the region as the

Table 3

Factor scores: factors expression in formation and use of innovation and investment potential in territorial units of Kharkiv region (Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

Territorial units	Factors			
	Social-economic	Settlement	Residential and commercial	Social-demographic
Administrative districts				
Balakliyskyi	-0,012943	-0,41622	1,25837	-0,05634
Barvinkivskyi	-0,103658	0,01885	-0,64006	-2,21852
Blyzniukivskyi	-0,161482	-1,04391	-1,01354	0,13044
Bohodukhivsk	-0,140554	-0,40688	0,07828	0,33706
Borivskyi	-0,168648	-0,50965	-0,76996	-0,32321
Valkivskyi	-0,186627	-0,46103	0,22094	0,45619
Velykoburlutskyi	-0,201767	-0,62000	-0,22711	0,36343
Vovchanskyi	-0,049111	-0,72581	1,26092	-0,75825
Dvorichanskyi	-0,194937	-0,25947	-0,61853	-0,20790
Derhachivskyi	-0,090785	0,20331	1,78549	0,58993
Zachepylivskyi	-0,290887	-0,27644	-0,81797	0,83563
Zmiivskyi	-0,069915	-0,68523	1,99984	-0,57279
Zolochivskyi	-0,110314	-0,59394	-0,60813	-0,44871
Izyumskyi	-0,070529	-0,79825	-0,09116	-1,70791
Kehychivskyi	-0,325372	-0,21456	-0,63277	1,97141
Kolomatskyi	-0,236911	0,04291	-0,90643	-0,91489
Krasnohradskyi	-0,156885	-0,04310	0,24018	0,79151
Krasnokutskyi	-0,171773	-0,76624	-0,67197	0,41429
Kupianskyi	-0,118932	-0,92323	-0,24131	-0,35192
Lozivskyi	-0,067930	-1,00313	-0,34547	-0,12779
Novovodolazkyi	-0,170216	-0,69465	-0,37033	0,23854
Pervomaiskyi	-0,132441	-0,50754	-0,19078	-0,92345
Pechenizkyi	-0,205303	0,40757	-0,44958	-1,11659
Sakhnovschynskyi	-0,184541	-0,91047	-1,47318	1,07339
Kharkivskyi	0,224979	-0,44772	3,56553	0,81125
Chuhuivskyi	-0,174030	-0,08061	1,06898	0,09612
Shevchenkivskui	-0,199909	-0,48414	-0,50272	0,71749
Towns of regional subordination				
Kharkiv	5,618901	0,36219	-0,42219	0,23541
Izyum	-0,139325	2,32396	0,14796	-2,81221
Pervomaiskyi	-0,444215	2,03714	-0,39122	1,31002
Kupiansk	-0,284051	2,02455	-0,02548	0,39090
Lozova	-0,223400	2,13779	0,02784	0,24184
Lyubotyn	-0,377041	1,53646	0,12833	0,00431
Chuhuiv	-0,379449	1,77749	-0,37276	1,53134

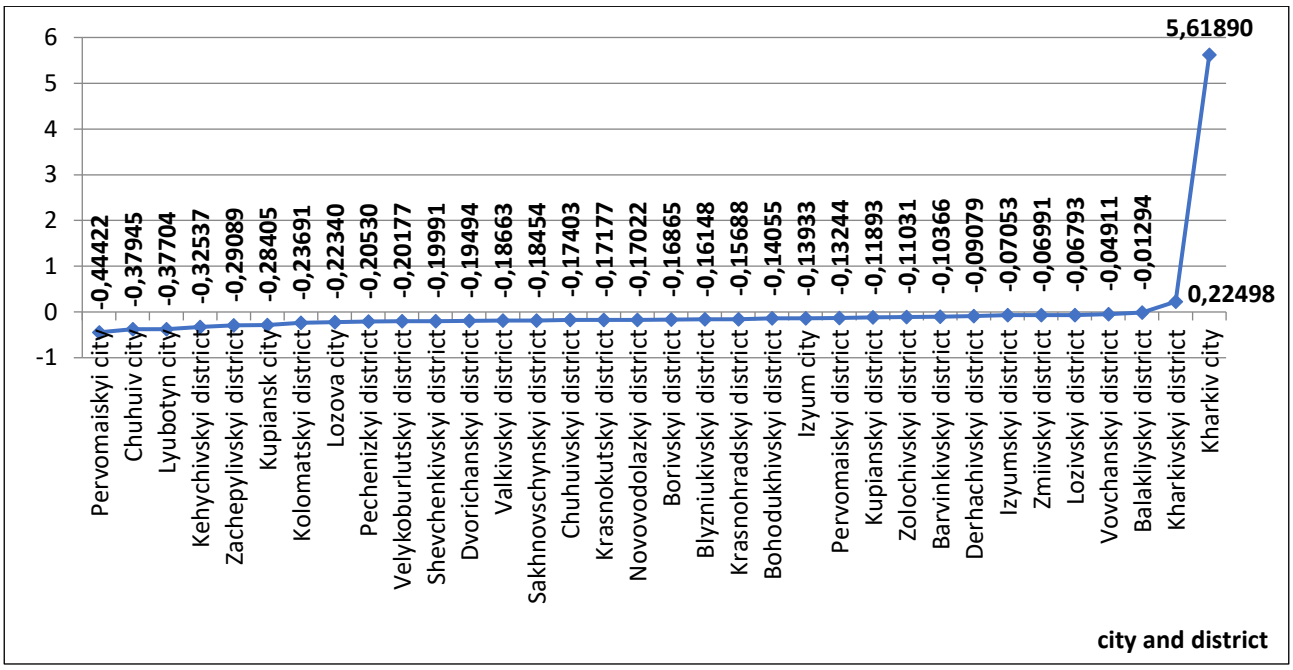

Fig. 3. Ranking of towns and districts of Kharkiv region as to the values of a social-economic factor, 2015 (Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

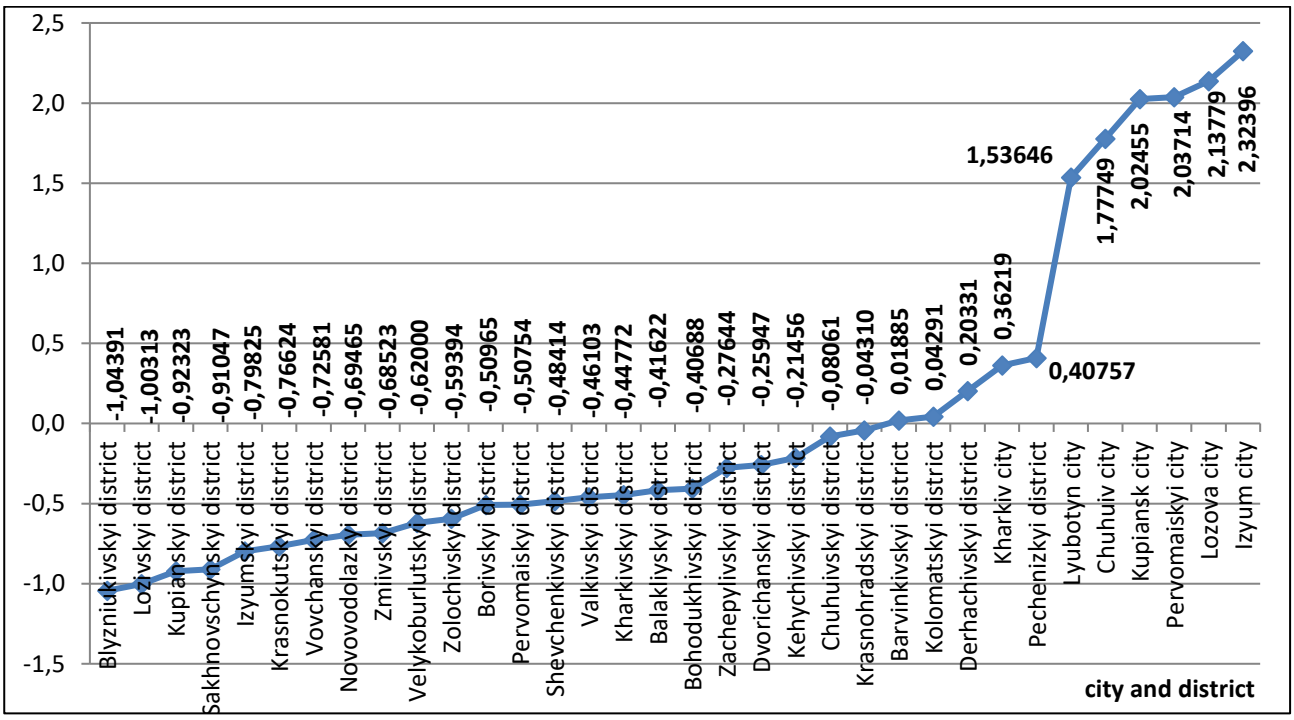

Fig. 4. Ranking of towns and districts of Kharkiv region as to the values of a settlement factor, 2015 (Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

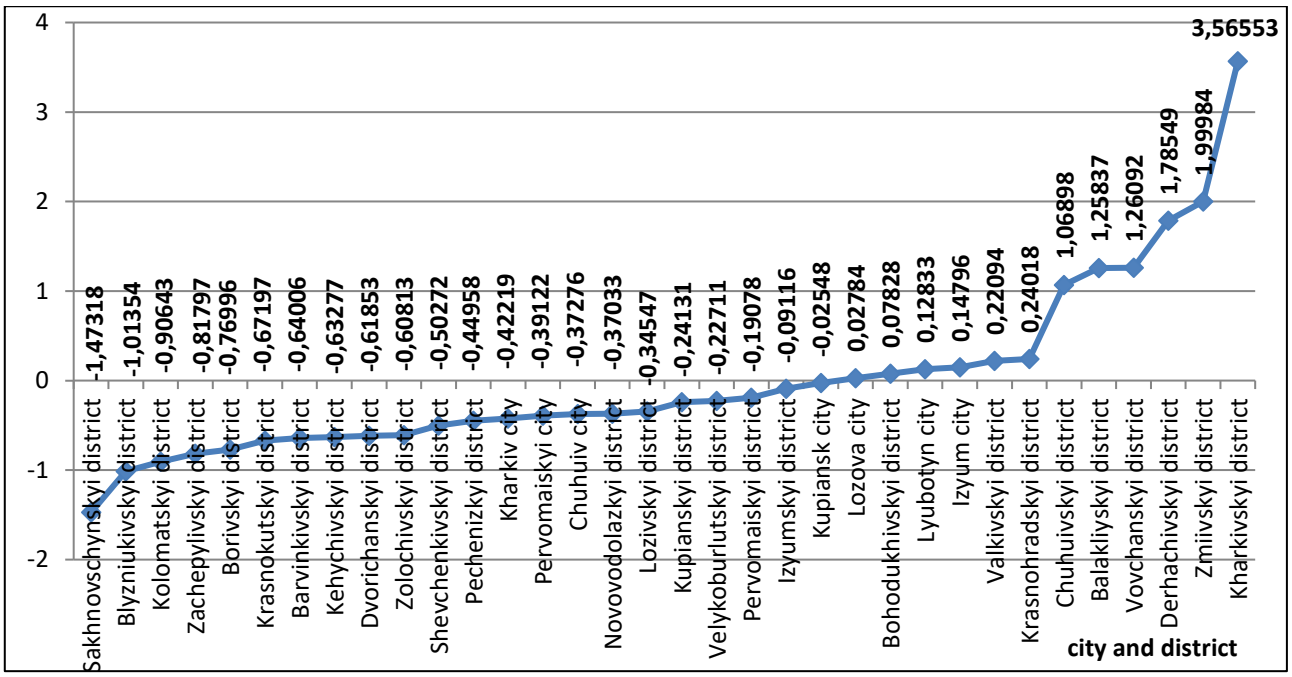

Fig. 5. Ranking of towns and districts of Kharkiv region as to the values of a residential and commercial factor, 2015
(Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

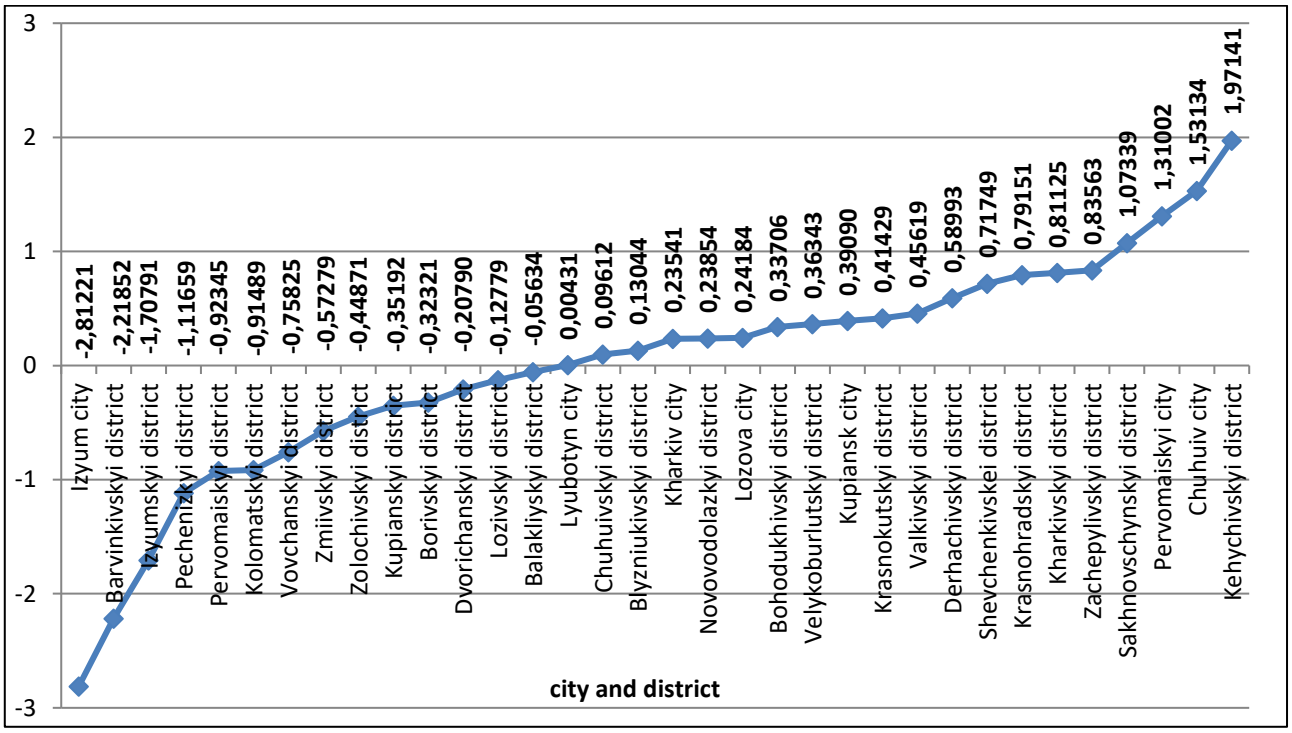

Fig. 6. Ranking of towns and districts of Kharkiv region as to the values of a social-demographic factor, 2015
(Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

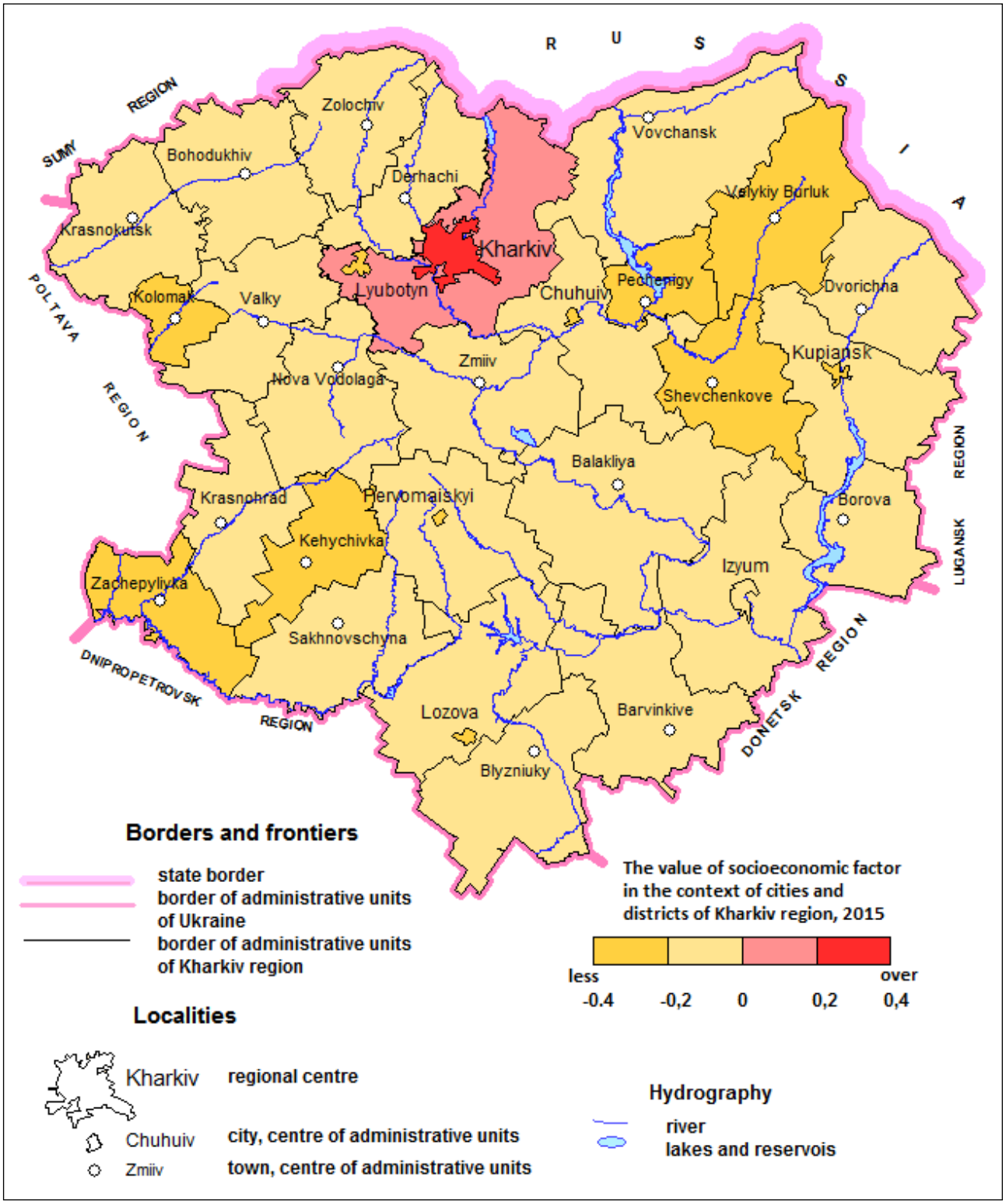

Fig. 7. The value of a social-economic factor in the context of towns and districts of Kharkiv region, 2015 (Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

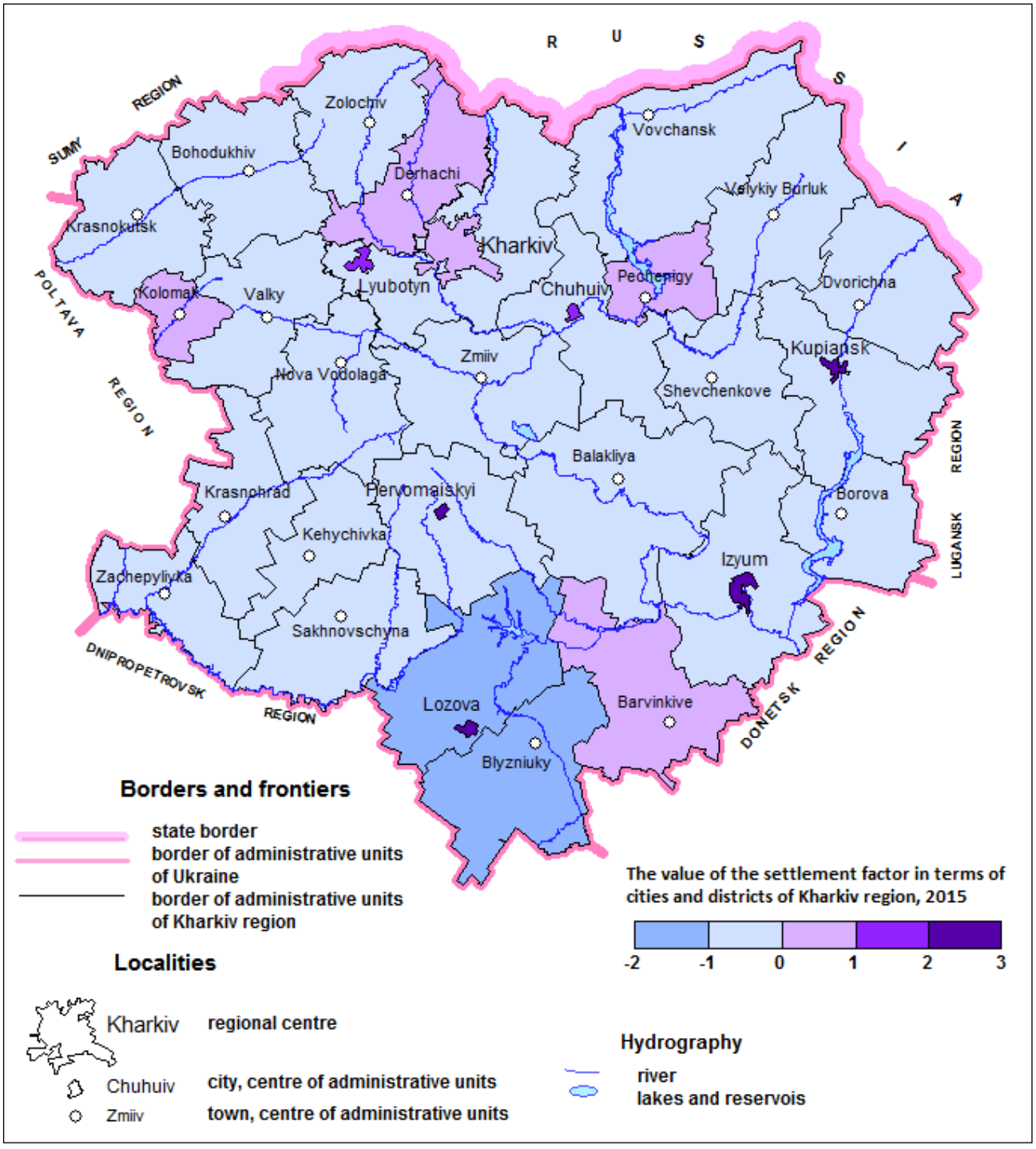

Fig. 8. The value of a settlement factor in terms of towns and districts of Kharkiv region, 2015 (Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

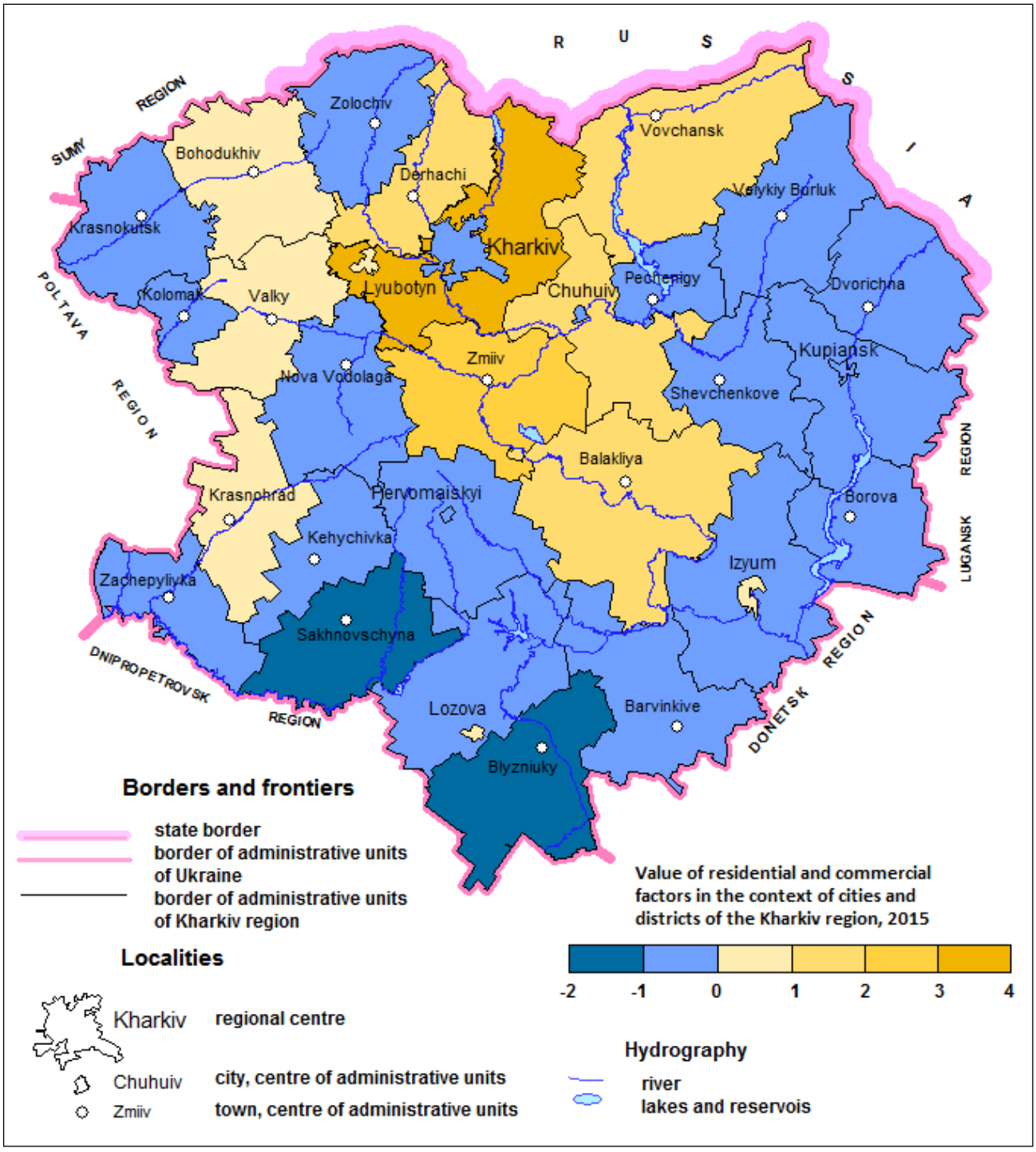

Fig. 9. Value of residential and commercial factors in the context of towns and districts of Kharkiv region, 2015
(Source: *Department of Statistics in the Kharkiv region, Niemets, Sehida, 2017*)

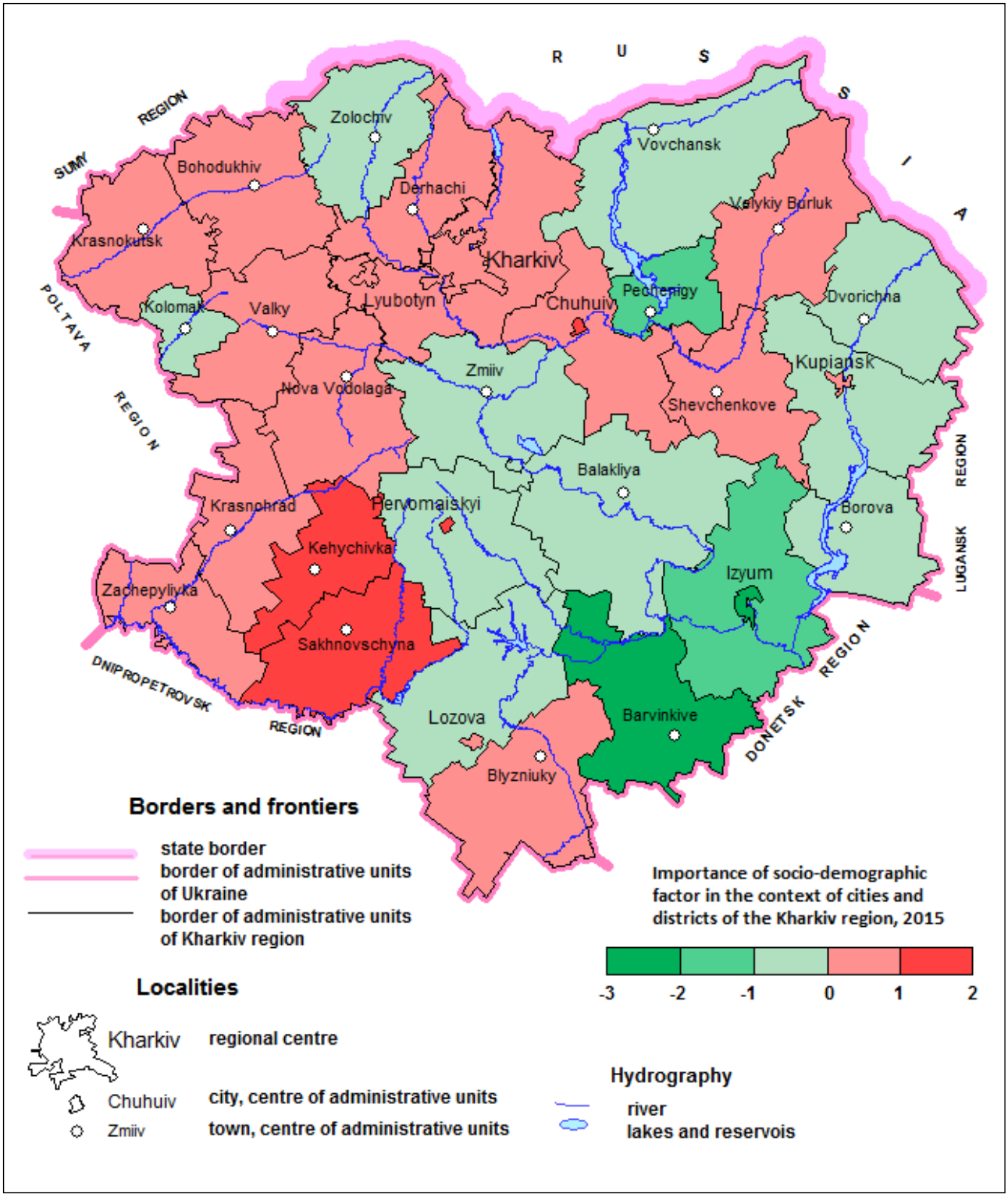

Fig. 10. The value of a social-demographic factor in the context of towns and districts of Kharkiv region, 2015
(Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

map show (*Figures 7-10*). Here, we do not see streamlined spatial structures.

The strongest effect of an inverse nature social-economic factor is observed in the city of Kharkiv and Kharkivskyi district (*Figures 3, 7*), due to the largest concentration of social and economic activity objects in the regional center.

Big values of this factor are also characteristic of districts located around Kharkiv (Volchansk, Zmiiv, Derhachi) and the areas where towns of regional subordination are located (Lozova, Izyum). Peripheral areas and towns with poor socio-economic indicators are not investment attractive and innovation active.

A settlement factor is also inverse by its function and most strongly manifested in the towns of regional subordination and highly urbanized areas (*Figures 4,*

8), as the highest innovation and investment potential is found in the towns and areas with predominant urban population (Izyum, Lozova, Pervomaisk, Kupiansk, Chuhuiv, Liubotyn, Kharkiv, Pechenihy, Derhachi districts, etc.) (*Niemets, Sehida & Husieva, 2015*).

The impact of residential and commercial factor (inverse) is most strongly felt in the areas located around Kharkiv (Kharkiv, Zmiiv, Derhachi, Vovchansk districts), i.e in its suburbs which, due to suburbian processes, are attractive for population relocation for permanent residence, building or buying a house, starting a business, renting premises, etc. (*Figures 5, 9*).

A social-demographic factor (inverse) is most evident in towns and districts with a relatively favorable demographic situation, high proportion of a core age group population (15-64 years), and at the same time, a small proportion of people aged 65+ which, on the one hand, provides a high labour resource potential of the territory, and, on the other hand, provides little demographic burden on working age people (*Figures 6, 10*).

Spatial pattern of innovation and investment potential distribution in Kharkiv region. To analyze the territorial characteristics of innovation and investment potential of Kharkiv region we used a *cluster analysis*, which allowed to split the districts and towns into clusters, i.e. groups, which included administrative territorial units with similar territorial characteristics of innovation and investment potential.

Cluster analysis is one of hierarchical classification methods that implies division of the original collection of objects or parameters into clusters (groups, classes) in multidimensional space. The coordinates of this space are all statistical indicators included in the sample. The clustering criterion is the minimum distance in the parameters space as the distance factor is a key concept in the cluster analysis.

In this study, as the dissimilarity measure we used *Euclidean distance*, which is the geometric distance in the multidimensional space between objects g and h (in this case, between every districts and towns of the region) and is calculated as follows (Pastor, 2010):

$$D_{gh} = \sqrt{\sum_{j=1}^{J}(x_{gj} - x_{hj})^2} \qquad (4)$$

where D_{gh} – the distance between the objects (or clusters centers); X_{gj}, X_{hj} – variables in objects g and h; J – the number of varibles.

There are many methods of cluster analysis. To group the administrative- territorial units in Kharkiv region according to a similar innovation and investment potential we have chosen the Ward method. First, when each object (town or district) is a separate cluster, the average values of all indexes are calculated. Then, squares of Euclidean distances are calculated from individual indicators of each cluster to the cluster estimated average. These distances are summed up, and a new cluster combines the clusters with the smallest increase in the total sum of distances (*Blizorukov, 2008*). Gradually, more and more administrative territorial units combine, aggregating clusters. With each step a greater number of different towns and areas are included into clusters. The last step combines all administrative territorial units into one cluster (*Mezentsev, 2004*). Thus, the obtained clusters are groups of administrative – territorial units that have similar development features. Implementation of clustering can trace the formation of regional groups and towns and their reorganization in time, allowing identification of the most stable trends and their established groups. This is very important for the development of perspective programs of optimal areas development. The results of cluster analysis are visually represented as a dendrogram – a tree-diagram containing n levels, each of which corresponds to one step in the sequential process of clusters consolidation (*Bureeva, 2007*).

To group the towns and districts of Kharkiv region by similar innovation and investment potential we selected nine indicators characterizing innovation and investment: capital investments (total, mln. UAH; per person, UAH per 1 person; the share of administrative-territorial unit in total volume, %), capital investments in housing construction (total, mln. UAH; per capita, UAH per capita; the share of the administrative-territorial unit in their total volume, %), innovation active enterprises (total number, units; the share of innovation active enterprises in total number of enterprises, %; the proportion of a given administrative-territorial unit in the total number of innovation active enterprises, %).

The resulting calculation data are visualized as a tree diagram (*Pastor, 2020*) (*Figures 11-12*) and presented at the map (*Figure 13*). Based on the *Figure 13*, it may be noted that Kharkiv region has a considerable territorial differentiation in formation and use of innovation and investment potential of its administrative units, which is primarily due to the specific socio-economic development.

The undisputed leader is the city of Kharkiv, as well as Kharkiv and Derhachi districts which are most attractive for investment and innovative activity, and in general, they have the most innovation and investment potential. Due to their favorable economic and geographical position (around Kharkiv), these areas are in many respects ahead of all other parts of the region as to the economic and social sphere development.

Implementation of clustering allowed us to group the towns and districts of Kharkiv region by

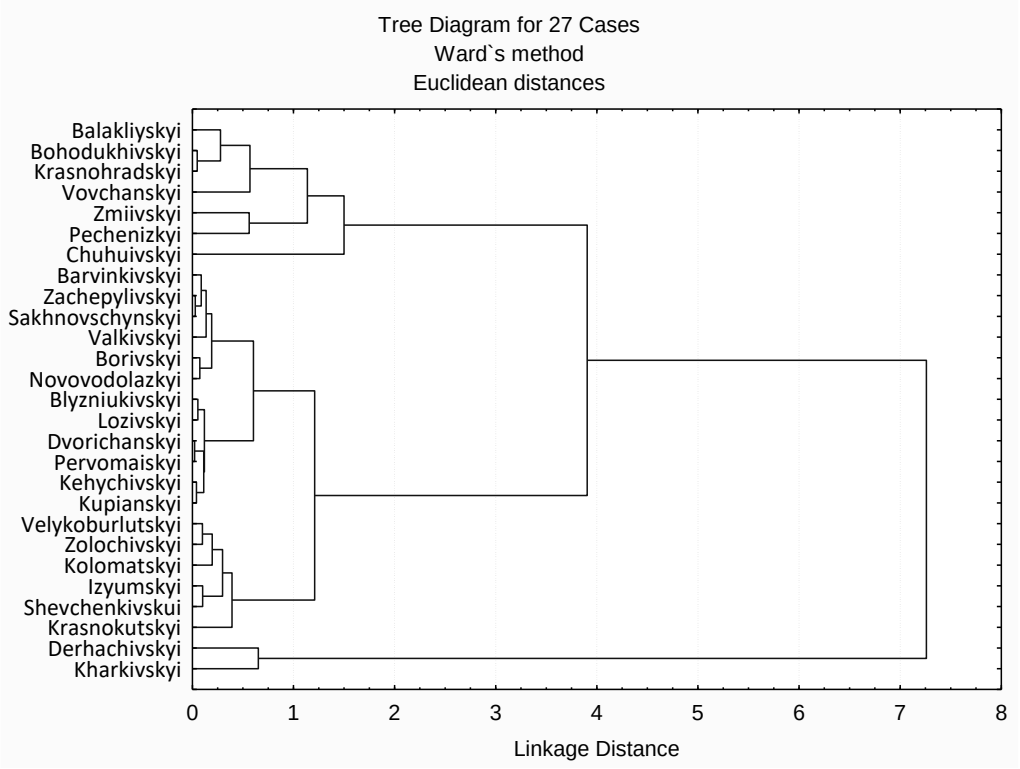

Fig. 11. Tree diagram of Kharkiv region districts clustering in terms of innovation and investment activity in 2015
(Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

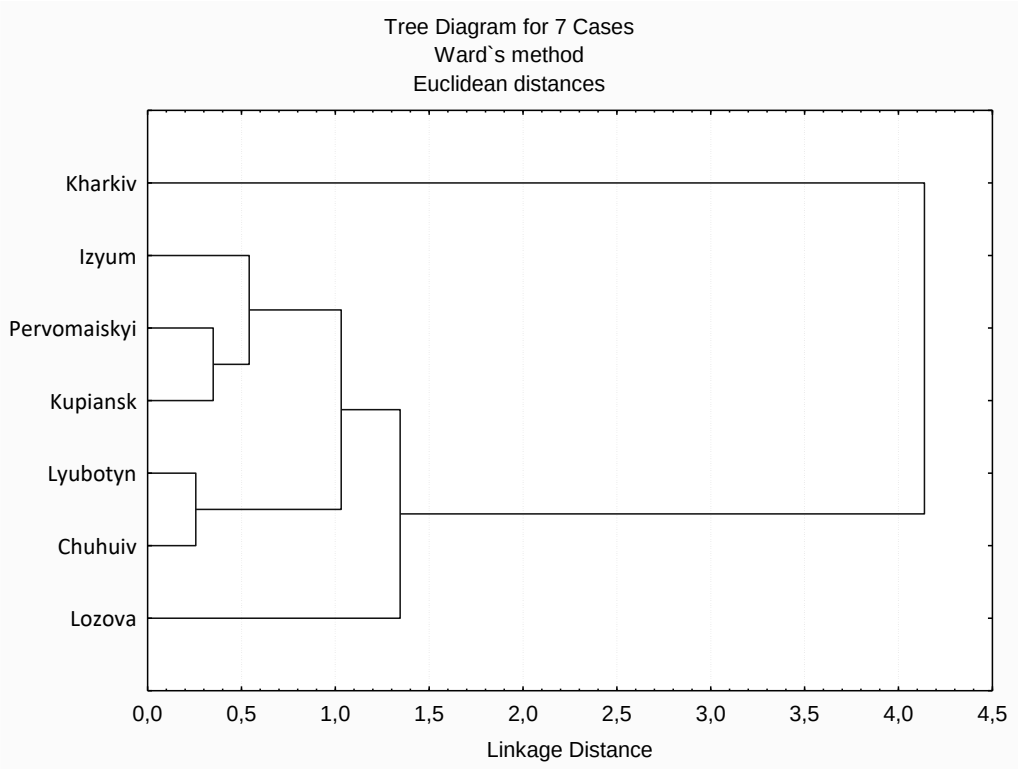

Fig. 12. Tree diagram of the towns clustering in Kharkiv region in terms of innovation and investment activity in 2015
(Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

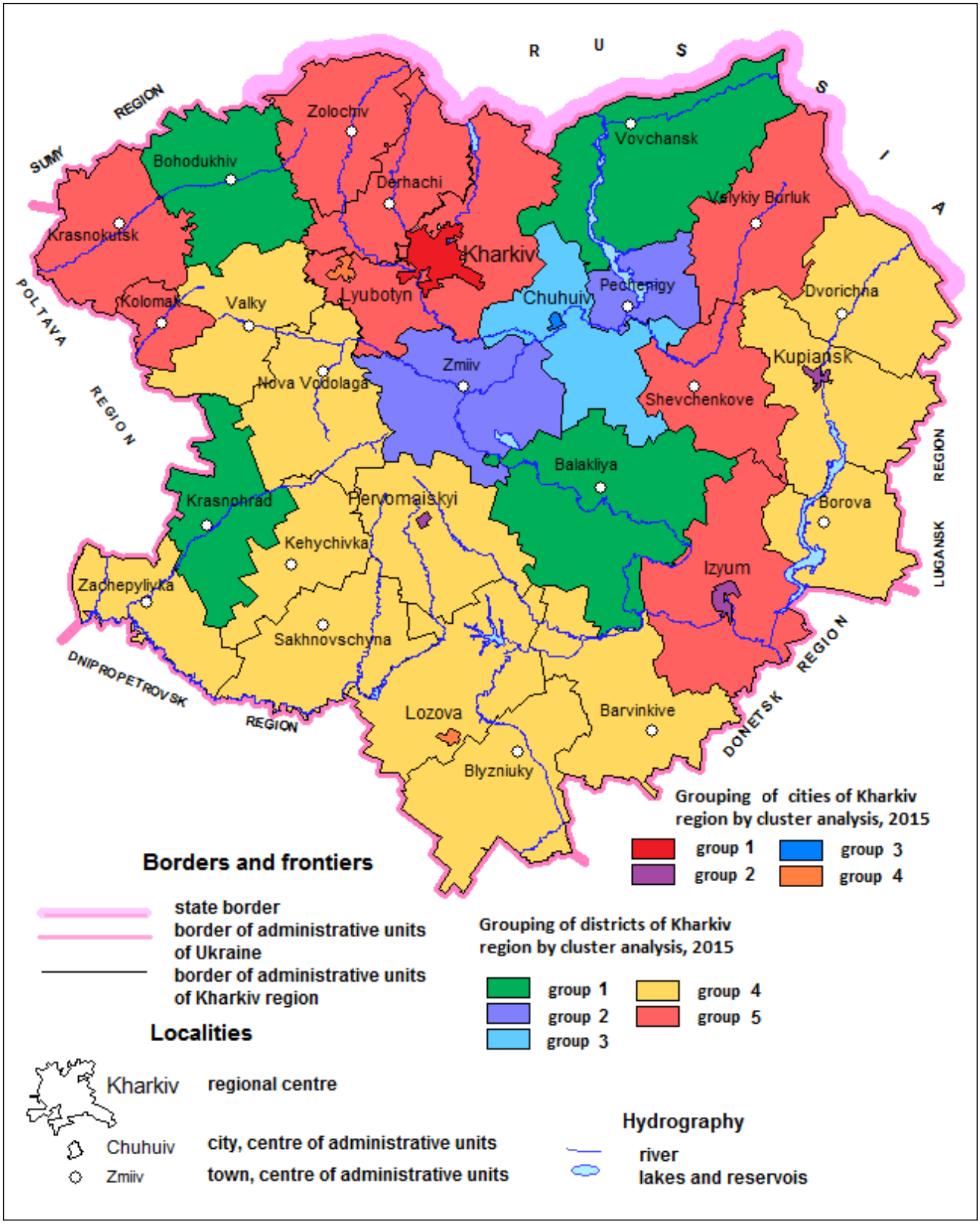

Fig. 13. Grouping of towns and districts of Kharkiv region
by similar innovation and investment activities in 2015
(Source: *Department of Statistics in the Kharkiv region; Niemets, Sehida, 2017*)

similar innovation and investment activity, to define the territorial distribution of innovation and investment potential of the region, which helps to identify problems and outline prospects for further use of its available resources. Analysis of settlement and socio-economic factors has shown that there is no obstacle for the development of innovation and investment activities in the region.

Conclusions. Present-day positioning of Kharkiv region and the city of Kharkiv as a "smart

region" defined as a modern, social city, a city of arts, research, tourist city, stipulates achievement of strategic development objectives, the key ones among them being creation of innovation active business, information and creative, scientific-educational city of the knowledge economy, development of innovation and investment activities in the region,transformation of Kharkiv into a Ukraine's leading innovation and investment center. The main factors of becoming a "smart economy" are innovation and research activities, development of science and education, expanding the scope of IT-technologies and intensive use of intellectual potential, investment in human capital, increase in the share of high-tech sector in the structure of social production, growth of value added share in the output created by the intellectual component, changes in the nature of human labor for creative and intellectual activity, etc.

Innovation and investment potential of Kharkiv region can be considered as a factor of "smart region transformation". The authors have determined the features of its formation and use in terms of a "smart-region" as well as the place of innovation and investment potential of Kharkiv region in national scale, factors identifying its formation in the region and territorial characteristics. The results of all the regions of Ukraine's ranking on selected statistical indicators of innovation and investment have shown that Kharkiv region occupies 2nd place in Ukraine by a combined indicator of formation and use of innovation and investment potential, second only to the city of Kyiv. Based on the factor analysis the formation and use of innovation and investment potential of Kharkiv region have been explained, factors affecting it have been analysed, administrative units in the region have been ranked for all sample indexes. It has been found out that the formation and use of innovation and investment potential of Kharkiv region are mostly influenced by four factors: social-economic, resettlement, residential and commercial, social-demographic. Factors values have also been calculated in terms of towns and districts of Kharkiv region.

Based on the cluster analysis, towns and districts of Kharkiv region have been grouped according to similarity in the key indicators of innovation and investment potential. It has been found out that Kharkiv region is characterized by a considerable territorial differentiation in the formation and use of innovation and investment potential of its administrative units, which is primarily due to the specific socio-economic development. The undisputed leader is the city of Kharkiv and Kharkivskyi and Derhachivskyi districts that have the highest investment attractiveness and innovative activity, and, in general, the most innovation and investment potential. Due to their favorable economic and geographical situation (proximity to Kharkiv), these areas by many indicators of economic and social development are ahead of all other areas of the region. Clustering allowed grouping the towns and districts of Kharkiv region by the similarity of their innovation and investment activity, to define the peculiarities of the territorial distribution of innovation and investment potential in the region, which helps identify problems and outline prospects for further use of its available resources.

The economic potential of the region, which includes natural and labour resources, innovation and investment potential is the basis for the territorial development, including its competitiveness, investment attractiveness, innovative activity, etc.

***Authors Contribution**: All authors have contributed equally to this work.*

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INNOVATION AND INVESTMENT POTENTIAL OF REGION AS A FACTOR OF ITS "SMART TRANSFORMATION" A CASE STUDY OF KHARKIV REGION (UKRAINE)

Formulation of the problem. Kharkiv region has recently been increasingly positioned as a "smart region" and Kharkiv as a "smart city". Moreover, the emergence of "smart economy" and the availability of people with jobs is one of the strategic objectives for the city development by 2020. The formation of Kharkiv region as an "intelligent region" with "smart economy" implies, among other objectives, a comprehensive development of innovation and investment activities in the region, its transformation into a Ukraine's leading innovation and investment center. A mandatory condition of the region's progressive socio-economic development is the economy of innovation type, which is impossible without investment.

The purpose of the article is to analyze the innovation and investment potential of Kharkiv region as a factor of its smart transformation, to identify the features of its formation and use in the aspect of the formation of Kharkiv region as a "smart-region".

Results. In this paper positioning of Kharkiv region and the city of Kharkiv as a smart region has been defined. The key goals and objectives of development towards a "smart economy", as well as basic factors of becoming "intelligent (smart) economy" are given. The authors analyze innovation and investment potential of Kharkiv region as a factor of its smart transformation; reveal the features of its formation and use in terms of Kharkiv region's formation as a "smart-region".

The place of Kharkiv region in the national dimension was determined according to individual indicators of innovation and investment activity and, in general, according to the innovation and investment potential with the help of the mathematical and statistical analysis. In particular, it is noted that Kharkiv region occupies the 2nd place in Ukraine in terms of the integral indicator of the formation and use of innovation and investment potential yielding only to Kyiv. According to the results of factor analysis, the factors of formation and use of innovation and investment potential of the Kharkiv region (socio-economic, resettlement, housing and trade and socio-demographic), their content (factor loadings) and intraregional peculiarities of influence (factor scales) were substantiated. Using a cluster analysis (Ward's method, Euclidean distance), grouping of cities and districts of Kharkiv region was conducted based on the similarity of their innovation and investment activities (4 groups of cities and 5 groups of districts were identified). The results of cluster analysis made it possible to conclude that Kharkiv region is characterized by considerable territorial differentiation of the peculiarities of the formation and use of the innovation and investment potential of its administrative and territorial units, which is primarily due to the specifics of their socio-economic development. The undisputed leaders are the city of Kharkiv and Kharkivsky and Dergachivsky counties, which are characterized by the highest investment attractiveness and innovative activity, and in general, the largest innovation and investment potential.

Thus, clustering allowed defining the features of innovation and investment potential in territorial distribution of the region, identifing problems and outline prospects for further use of the region's available resources.

Keywords: smart economy, smart transformation, innovation and investment potential, Kharkiv, Ukraine.

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