

## **Perfecting of mathematical tools for forecasting the country development vectors on the basis of economic and demographic parameters system analysis**

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### **ABSTRACT**

Under the conditions of activeglobe community activities aimed at solving systemic problems in socio-economic development the scientific and practical interest to the study of demo-economic processes applying mathematical tools increases objectively. This issue is especially actual for Ukraine, which had economic conditions similar to many EU countries, but got unsatisfactory results in the market economy functioning. Therefore, it is the task of paramount importance to establish cause-effect relationships between key demo-economic indicators of Ukraine and a country with a set of similar conditions of development (Poland) to adjust the strategic goals of sustainable development of Ukraine towards the meeting of EU demographic standards. The results of the analysis of the demo-economic situation in Ukraine and Poland in 2000-2017 revealed opposite trends in development. The human factor proved to be a strong component of development for both countries. The methodical approach to the assessment of the regional level of human development, based on the improvement of the mathematical tools for forecasting the development vectors of the country, is proposed. It is based on the grouping of country regions according to certain demographic parameters. Common and peculiar issues of human development in different regions of Ukraine are systematized upon the basis of clusterization. The established regularities of demo-economic development of entire Ukraine and regional features, the levers of state regulation of human potential formation of Poland were taken into account and laid as the basis of scientific and practical recommendations for adjusting the Strategy of Sustainable Development of Ukraine.

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### **1. Introduction**

Socio-economic development of any country depends on a combination of factors, among which the demographic ones take the important place. The latter determine the terms for the reproduction of the population in general and the part which wants to realize their ability to work. Being a driving factor in social

production, the workforce, transformed into the notion of "human capital" under modern conditions, is at the same time a criterion for economic development and competitiveness of the country, the root cause of progressive changes in society, an economic basis for ensuring equilibrium in the labor market, the quality of working life and human development in general.

In their turn, the quantitative and qualitative characteristics of human capital are dependent on the course of demographic processes. The demographic quality of the population determines both the labor activity of the population, their productive capacities, and the economic results of the country.

Taking into account the above-mentioned circumstances, the importance and significance of demographic development as a component of strategic changes in the economy is acknowledged by all countries of the world [1], [2]. However, despite the development of policy and procedure documents in the field of sustainable development, there are still many problems in the demographic area which require a thorough study applying mathematical tools.

Moreover, understanding of the peculiarities of the demographic processes occurrence in different systems which have certain features of functioning must be taken into consideration. In our opinion, the analysis of these processes should be carried out on the basis of a comparative assessment of the demo-economic trends of countries which had similar initial conditions for the formation of a market economy and a comparison of such trends of the countries which under the current conditions are donors and recipients for the development of each other's labour market.

The current demographic situation in Europe, unlike other regions of the world, is characterized by a low birth rate, an increase in life expectancy and a general decrease in the number of indigenous people and their share in the structure of the supply on the national labor market. So, in the 21st century, virtually all EU member states are experiencing the lowest birthrate ever recorded in history. According to the most recent data available birth rates dropped to 1.2 children per woman in Italy and Spain, in Germany this figure is 1.3 children, in Poland it amounts to 1.4, Switzerland gives 1.5, France and Denmark - 1.7, Ireland - 2 [3]. The age group from 0 to 15 years is shrinking; therefore, Europe is expected to reduce the human capital in the future.

Ukraine is a European state which is not a part of the EU. At the same time, the common borders with the EU determine the inevitable direct impact of the processes taking place in Ukraine on the EU states. That is why the sooner Ukraine overcomes the existing difficulties, the fewer are the problems associated with the "eastern" neighbor, which, in its turn, releases resources for resolving other urgent issues.

Ukraine has common demographic problems with EU countries, in particular, with regard to low birth rates, aging population, large-scale internal migration, including those ones, arisen through military conflicts, etc. In consequence, many analysts consider that the negative dynamics of the growth of the Ukrainian population threatens the country with inevitable catastrophe [4].

The demographic crisis which Ukraine is experiencing is considered to be one of the main real and potential threats to the country's national security in the social and humanitarian spheres. Loss of human capital due to mortality and catastrophic outflow of the working-age population affect the economic, military and intellectual potential of the state significantly.

The following issues arise:

- whether the demographic changes taking place in Ukraine are similar with trends in European countries demographic processes;
- what are the peculiarities of these processes, taking into account the regional differences of their development;
- what measures should be taken to bring demographic changes in Ukraine closer to EU demographic standards.

So as to answer the questions put in this study, we analyze the demographic processes in Ukraine and compare them with the trends of similar processes in Poland. The choice of the object of comparison is explained by the fact that it is Poland which is one of the EU countries, which according to its historical traditions, geography and mentality is close to Ukraine. Both countries survived the dictatorship, the planned economy and the deficit, but Poland has achieved much greater economic success, became a member of the EU. Ukraine, however, has just entered this path. In addition, as shown in the previous studies [5], in 2015 Poland was in a single cluster with Ukraine according to certain demographic and economic indicators, which is also an indisputable proof of the commonality of both countries development characteristics.

## 2. Literature review

Problems of demo-economics have been the subject of scientific research for a long time starting with the classics of economic science A. Smith, T. Malthus, J. Mill and ending with modern scholars who devote their works to various issues of human development. Among the latter ones we come across the socio-demographic aspects of social policy, in particular demographics and population economics, labor market, demographic patterns of reproduction of labor potential, estimation of actual population losses during demographic disasters, possibilities of early diagnosis of diseases of the population [6], integrated assessment of the system of interrelated parameters of economic, demographic, social policy, problems of urbanization of the population [7] etc. (E. Libanova, I. Kurilo, B. Krimer, O. Malinovska, N. Levchuk, L. Lisogor, A. Grishnova, N. Ryngach, A. Rogozhin, P. Shevchuk, A. Romaniuk, T. Gladun, N. Kulik, A. Jakubowska, Z. Horváthová, A. Kurowska, M. Myck, K. Wrohlich, M.A.R. Estrada, S.-F. Yap, N.A. BintiIsmail and others). Besides, methodological researches of N. Ringach, A. Jacobiy, M. Tezjakov, M. Uvarov, M. Diatropov, M. Dolishny, I. Gudzelyak, M. Koversky, A. Mishchuk, N. Pritsyuk, M. Flyaga and others are essential for studying the demographic situation.

Considerable attention in recent scientific publications of the subject domain is paid to the study of the course of individual demographic processes. Thus, E. Libanova [8] conducted an in-depth assessment of the structure, scale, causes and socio-economic implications of migration in terms of countries attracting migrants. The scientist determined that the economic factors of migration, remaining the main motives of this demographic process, operate in tandem with other elements of the mental environment. In addition, the main results of this research are based on the comparison of wages of Ukrainians with the EU member states as a priority economic criterion.

Crosscountry and intercountry comparison is quite often used in scientific research in this subject area, first of all, to explain the difference in the course of individual parameters of population reproduction. In particular, L. Kurilo et al. [9] discussed the general features and peculiarities of the present situation of fertility and the formation of marital and family relations in Ukraine and Belarus.

In the work of B. Krimer [10] attention is focused upon the birth rateprocess of Ukrainian population and its relevance to the global process of demographic transition, specific features of the transformation of of Ukrainian population birth rateagainst the background of developed countries.

The scientific works of N. Levchuk, L. Lisogor, E. Libanova, N. Kulik, O. Gladun are devoted to the relationship between the demographic quality of the population and the state of the national labor market; the works of A. Jakubowska and Z. Horváthová [11] dwell upon the interrelation between the health of the nation and the level of economic development; A. Kurowska et al. [12] focus on the interrelation between social payments and occupation of the population; M. A. R. Estrada et al. [13] emphasise the connection between unemployment and the size of wages.

The collective monograph of the scientists of the Institute of Demography and Social Studies named after N.V. Ptuha of the National Academy of Sciences of Ukraine [14] considersthe demographic factors as the main determinants and prerequisites for the development of innovative employment, the main risks and threats have been identified, and recommendations for stimulating the development of this type of employment were developed. In the work of N. Levchuk [15] it was determined that the prerequisite for the formation of innovative employment of the population is health and life expectancy in the country, while high premature mortality leads to significant losses of labor potential and threatens the equilibrium in the labor market.

The economic evaluation of the effects of negative trends in the course of demographic processes was studied by many scholars, including N. Ringach, R. Nifantova, S. Shipitsina, O. Frolov, D. Shmakov, B. Prokhorov and others. In particular, in the work of N. Ryngach [16], the economic evaluation of lost years of potential life in the results of premature mortality was carried out. In general, publications in this area are aimed at the economic evaluation of partial processes.

Thus, the results of the analysis of modern scientific publications made by the authors brought to light the following gaps in the study of demographic processes as the basis for the formation of an effective strategy for sustainable development of the country and the functioning of the national labor market:

- predominance of analyses of partial demographic processes, especially birth rate, mortality, migration;
- lack of an integrated approach covering a wide range of partial demographic processes;
- failure to take into account the peculiarities of the demographic situation in the country in a regional context;
- disregard of economic estimates of the course of demographic processes or their reduction to intermediate

criteria, in particular, to the comparative analysis according to wage rates;

- unmethodical assessments of the relationship between the demographic quality of the population and the state of the national labor market;
- application of the base of the intercountry comparison (sample of countries) in the field of demography without proper justification, which reduces the following scientific and practical recommendations for sustainable development of the country to the general character.

The necessity to overcome these scientific gaps creates the basis for in-depth study of demographic processes and the possibility of avoiding a significant error in the results of the research, and thus setting clear strategic goals for sustainable development of the country.

The aim of study is to establish with the application of modern mathematical tools the main cause-and-effect relationships between the key demo-economic indicators of Ukraine and a country with a set of similar conditions of development (Poland) in order to adjust the strategic goals of sustainable development of Ukraine towards the achievement of EU standards in the field of demography.

### **3. Materials and methods**

To achieve the goal methods of formal logic were used. Analogy and comparison enabled identifying common and particular trends in the development of demographic and economic processes in Ukraine and Poland, analysis gave opportunity to prove the predominant importance of intensive demographic factors on the country's economic growth, synthesis allowed formulating a program of measures to bring Ukraine closer to the standards of EU development. The application of methods of dialectics, namely the method of scientific abstraction, made it possible to prove the ineffectiveness of the extensive directions of demographic development for Ukraine. Throughout the study, dynamic rows, graphical and tabular presentation methods were widely used.

At the stage of forming a system of indicators characterizing the level of demographic and economic development of Ukraine and Poland, the following aspects were taken into account:

- demographic conditions of development specific to the regions of Ukraine;
- availability of official statistical information for a certain period of time (for building dynamics series), ensuring comparability of indicators;
- indicators used in their reports by the State Statistics Service of Ukraine and the Central Statistical Office of Poland;
- the possibility of using indicators from the list used by international organizations (World Bank, International Labor Organization, UN, etc.);

The estimation of the human development level of different regions of Ukraine on the basis of the main demographic indicators is carried out according to a multidimensional statistical procedure such as a cluster analysis, which does not require a priori assumptions about the data set when applied to the tasks of such evaluation, which does not impose restrictions on the representation of the objects under study, makes it possible to analyze indicators of different data types (interval, binary). An important factor is that variables are measured on comparable scales, i.e., the normalization of indicators is used, for which the partial coefficients are calculated.

Regions of Ukraine and Kiev (2017) were selected as objects of clusterization. The grouping of regions was conducted according to such 10 indicators as the number of available population; the number of permanent residents (estimated) at the age of 16-59 years; the number of live births; average life expectancy at birth by gender; economically active population aged 15-70; unemployed population aged 15-70; the number of students of comprehensive educational institutions per 10000 people; the number of students of higher educational institutions per 10000 people; income available per capita; the share of population with average total monthly income per capita below the subsistence minimum.

To determine the number of clusters the tree-like clustering method using the Statistica program was applied. To solve the problem of regions clustering by the determined factors the most adequate is the direct way of computing Euclidean distances between objects in a multidimensional space. Euclidean distance is a geometric distance in a multidimensional space which is calculated by the formula [17]:

$$L = \sqrt{\sum_i (x_i - y_i)^2} \quad (1)$$

To solve the problem of determining the regions belonging to the corresponding clusters in the process of their

evaluation, a method based on the application of the  $k$ -medium algorithm is chosen.

The  $k$ -medium algorithm builds  $k$  clusters that contain data of regions located at aslong distances from each other as possible. The main type of tasks solved by the  $k$ -medium algorithm is the presence of assumptions (hypotheses) on the number of clusters, besides, they must be as different as possible.

The clusterization of the regions by the  $k$ -medium method divides the input set of vectors containing their key characteristics for  $k$  clusters  $S_i = i(1,2,\dots,k)$ , the centroid  $c_i$  is connected with each of them. We denote the infinity of input vectors  $S = \{x\}$ ,  $|S| = n$ . Let  $D(x, c)$ be the distance between the vector  $x$  and the centroidoid  $c$ . In this case the unweighted Euclidean distance between the vector and the centroid is used to form the distance between the vectors. We denote the set of centroids obtained on the iteration  $t$ ,  $SC_t = \{c_i\}$ . The  $k$ -medium clustering algorithm in application to the regions of Ukraine envisages the following steps:

1. We determine  $t = 0$  and fix the initial position of centroids  $SC_0$ .
2. For a given set of centroids  $SC_t$ ,we perform the operations described in Sections 2.1 and 2.2, and obtain an improved set of centroids  $SC_{t+1}$ :
- 2.1. We find such a partition of the set of vectors of the characteristics of the regions  $S$ , which divides them by  $k$  clusters  $S_i = i(1,2,\dots,k)$  and meets the condition  $S_i = \{x / D(x, c_i) \leq D(x, c_j) \forall j \neq i\}$ .
- 2.2. We compute the centroid for each cluster  $S_i = i(1,2,\dots,k)$ , to obtain a new set of centroids  $SC_{t+1}$ :

$$c_{ij} = \frac{1}{m_i} \cdot (\sum_{i=1}^{m_i} x_{ij}), j = 1,2, \dots, d \quad (2)$$

where  $m_i$ is the number of vectors belonging to the  $S_i$ .3. We calculate  $\mathbf{E}^2$

$$\mathbf{E}^2 = \sum_{x \in S} \mathbf{D}^2(\mathbf{x}, \mathbf{c}) \quad (3)$$

If it differs from the previous iteration for a rather small amount, we complete the process. Otherwise, we assign  $t \leftarrow t + 1$  and return to step 2. The algorithm is guaranteed to coincide with the finite number of iterations. The clustering error and the number of iterations depend on the initial choice of centroids, so the usual practice is to run the  $k$ -medium several times with different initial data in the centroid [18].

#### 4. Results

The results of the retrospective analysis of demoeconomic graphic processes according to [19], [20] revealed the following issues:

-there was a decrease in the proportion of able-bodied peopleinUkraine over 2005-2017; the economic load factor has increased, the population employment has decreased, while unemployment has risen. Among the positive changes we observe the increase in the proportion of people under the age of 14 and the average life expectancy;

-there was a deterioration of structural age indicatorsin Poland in 2005-2017, which also led to an increase in the economic load factor. However, the qualitative characteristics of labor resources have improved which means increased employment, reduced unemployment.

The results of the use of labor resources in Ukraine and Poland in 2000-2017 were estimated by GDP per capita (ths. USD), which for a long time has served as a measure of a society welfare and level of development.

According to the data [21], the same (fluctuating) changes in trends are observed in GDP per capita both in Ukraine and in Poland over 2000-2017. The lowest value of GDP was observed in 2000: it amounted to 663 US dollarsin Ukraine and to 4459 USdollars in Poland. The highest value indicator was reachedin 2014. It mounted to4073US dollars in Ukraine and to 14237 US dollars in Poland.GDP per capita in Poland exceeded Ukraine comparable figure in some years by more than 7 times with regulargap growth. Therefore, Ukrainians become poorer every year compared to their European neighbors. Besides, as the preliminary analysis showed, Ukraine with a larger population and almost the same proportion of able-bodied people had a considerably higher share of labor participation and a higher level of employment of the able-bodied population over 2005-2017. Hence, quantitative indicators of the demographic development of the country do not have a direct impact on the efficiency of the economyin a modern society.

In accordance with recent UNFPA scientists'research [22], the world's population growth to 9.7 billion people takes place due to the least developed countries. Developed countries of Europe and developing countries including Ukraineexpect the reduction of the existing populationin the nearest future. Therefore, the epoch of

the significance of quantitative parameters of the demographic component of the economic system of such countries has exhausted itself. Priority is given to qualitative parameters of demographic factors such as education, productivity, etc..."From an economic perspective, what matters for economic growth, household income, and living standards is not the number of people who work but rather the productivity of those who work, and how the benefits are redistributed in society. Because of relatively low labor productivity and labor compensation, even a large number of working people in the least-developed countries can support only a small number of dependents. Inversely, high labor productivity and labor compensation in developed countries allow a small number of working people to support a large number of dependents" [23]. Countries that are driven by sustainable economic growth must first invest in the real economy, technological advances and human capital. And while taking into account the consequences of industrialization [24]. Nowadays one of the main criteria for assessing the qualitative characteristics of the demographic component (human capital) of the country is the Human Development Index (HDI). This is an integral indicator that is calculated annually for interstate comparison and measuring of living standards, literacy, education and longevity as the main characteristics of human potential of the studied territory. The data has been published in the annual UN report on human development since 1990. Regarding HDI indicator in 2017 [25], Ukraine belongs to a group of countries with high human development, while Poland is a very high human development state. On the whole, Poland ranks 33rd and Ukraine as little as 88th in the overall list of countries. However, in 1990 in terms of human development both countries had almost the same value of this coefficient (Ukraine-0.701, Poland - 0.709). After 25 years Poland was able to achieve significant results in human development and provided a growth rate of 0.865 owing to creation of both economic and social conditions for the development of its population welfare, while Ukraine had a human development rate only at the level 0.751 in 2017.

It is worth mentioning that due to higher rates of other countries' development Ukraine has been constantly losing its rating positions since 2011. Thus, Ukraine with a human development rate of 0.734 occupied the 69th place in 2010, and only 88th one out of 189 countries in 2017. According to the index components, Ukraine has relatively good state of affairs with education and literacy but the situation concerning health and longevity is far worse, and it is the worst one as regards the standard of living (economic development). Unfortunately, this tendency has been persisting for many years. A decisive role of the human factor in shaping the world image of Ukraine is also evidenced by the structure of the Inclusive Development Index (IDI) which is an indicator proposed as a criterion for assessing the inclusive development of national economic systems at the World Economic Forum in Davos in January 2017. IDI was proposed to be used as an alternative to GDP per capita. Scientists in the world have long been discussing the imperfection of GDP per capita [26], [27], [28]. Unlike GDP per capita, IDI provides a more comprehensive assessment of the country's economic development and reflects a significant number of factors that can stimulate inclusive growth.

The report of the World Economic Forum on Ukraine states:"Ukraine ranks 47th on the IDI, scoring measurably lower than it did five years ago. Continuing hostilities in the east of the country are possibly rolling back some progress, as they disproportionately affect the least well-off, driving talented people to leave the country for opportunities elsewhere. Ukraine has a low dependency ratio (43.3%), but performs poorly on all other measures of intergenerational equity. It also has one of the highest levels of wealth inequality of all developing countries. On the positive side, it has low income inequality and poverty. The Framework indicates that its education system is supportive of inclusive growth, with high enrollment rates and equitable outcomes for students across socioeconomic levels. The middle class remains large, and good healthcare and unemployment benefits help Ukraine rank first in its income group on social protection" [29]. Some other tendencies are characteristic of the Polish economic system, namely:"Poland ranks 4th among developing economies on the IDI, its high score of 4.57 reflecting strengths in GDP per capita, labor productivity, healthy-life expectancy, and median living standards, in addition to relatively low poverty and inequality. In terms of Framework results, Poland tops the education and skills pillar: education and training are of comparatively good quality, and outcomes are relatively equitable among students from different income groups. The country also has the strongest social protection system among peers, though its tax system would benefit from reforms to strengthen incentives to work and invest" [30].

The human factor (the intellectual potential of the population, the level and accessibility of education, the corresponding infrastructure, etc.), according to the conclusion of international organizations, is a strong component of development both for Ukraine and for Poland. However, the essential difference is that conditions have been created in Poland unlike in Ukraine to develop human potential. Moreover, balanced

social policy at the national level have been carried out for many years, which enabled to ensure a significant increase in the productivity of the economic system and create a solid foundation for its further development. The successes that Poland has achieved over the past few years is a direct confirmation of it.

We believe that presence of a high level of human development in Ukraine is due mainly to the "inertia movement", that is, the use of the material and technical base, staffing, methodological support that was created in the days of the USSR or for the first years of Ukraine independence. At the same time, the presence of problems in the Ukrainian economy, which was highlighted by international experts within the framework of the World Economic Forum in Davos in January 2017, suggests that the level of human development of Ukrainian society alone is no longer able to ensure a stable position of the country in world community. It is a common knowledge that Ukraine has a significant number of problems. These unresolved issues may have a very negative impact on the human potential of the country in the nearest future. According to the report of World Economic Forum [31] Ukraine was among the low-income countries in 2017. This group also includes Guatemala, Tunisia, Cambodia, which, according to the IDI, have better performance than Ukraine. Such countries as Colombia, Bolivia, Mongolia, Nicaragua, Bangladesh, Tunisia have close values of the IDI. In terms of corruption Ukraine is among the top five notorious leaders out of 37 countries. It is ahead of Yemen, Nicaragua, Mauritania and the Kyrgyz Republic. Ukraine has significant problems with investment, small business development and tax burden. In addition to Ukraine two more European countries such as Albania and Moldova were included in the group of low-middle income countries.

The above data testify to the inconsistency of human development level of Ukrainian society and the conditions which are to ensure its further development. Furthermore, the demographic situation is quite different in different regions of the country. Hence, it is impossible to determine the index of human development according to the world methodology in all the regions of Ukraine, as there is no necessary statistical information. Today, the calculation of the index of regional human development is carried out in accordance with the methodology approved by the decree of the Cabinet of Ministers of [32]. According to Annex 1 of the "Procedure for calculating the regional human development index", the indicators used to calculate the regional human development index (RHDI) are grouped in three directions: long and healthy life; welfare and decent working conditions; education.

According to the Ministry of Regional Development, Construction and Housing and Communal Services of Ukraine, RHDI ranged from 0.61 to 0.8 and its average value in Ukraine in 2017 was 0.65 [33]. The lowest value was obtained in the Kirovograd and Chernihiv regions, and the highest one was recorded in Kyiv. Most regions of Ukraine ranked 0.63 (Poltava, Mykolaiv, Odesa, Vinnitsa, Zaporozhye), while the average index value (0.65) was obtained in the Volyn, Ivano-Frankivsk, and Rivne regions. RHDI does not differ considerably all over the regions of Ukraine, so it is difficult to group them and identify the lag in the development of human potential of one region from another.

One of the modern mathematical tools for grouping regions according to certain well-known indicators is a cluster analysis, which is widely used to predict socio-economic phenomena and identify priority areas for regional development.

The results of distribution of Ukrainian regions into clusters according to main demographic indicators are shown in Fig. 1.

Correspondingly, the dendrogram of regions of Ukraine according to demographic indicators is expedient to split into three clusters.

Graphical interpretation of the results of cluster analysis of Ukrainian regions grouping by means of *k*-medium method according to main demographic indicators is presented in Fig. 2.

Three clusters were obtained as a result of clusterization: the first of them included five regions (Dnipro Petrovsk, Lviv, Odesa, Kharkiv and Kyiv), the second cluster covered eleven ones (Zhytomyr, Kirovograd, Mykolaiv, Poltava, Sumy, Ternopil, Kherson, Khmelnytsky, Cherkasy, Chernivtsi, Chernihiv regions), seven regions belong to the third cluster, they are Vinnitsa, Volyn, Zakarpattia, Zaporozhye, Ivano-Frankivsk, Kiev, Rivne.

The regions of the first cluster with the highest population figures, the number of permanent residents aged 16-59, the number of live births, the number of students of higher educational institutions, the highest disposable income per capita and the share of population with average per capita equivalent of total income per month below the subsistence minimum, are economically developed regions.

The regions of the third cluster aren't numerous, but have the potential to develop education. The second cluster grouped the largest number of regions of Ukraine, but the performance is the worst in this cluster.

The results of cluster analysis indicate that the vast majority of regions of Ukraine have significant

demographic problems that have not been solved over a long period of time. In addition, general feature of all areas is unemployment and impoverishment of the population. It was the reason for the low demographic and economic indicators of Ukraine development at the national level [34].

It should be noted that the three clusters are almost indistinguishable from each other in the following indicators: average expected life expectancy by sex, the economically active population aged 15-70, the unemployment rate of the population aged 15-70 and percentage of the population with average total monthly income below the subsistence minimum. The largest difference between demographic indicators is observed between the first and second clusters, less significant one between the second and third clusters.

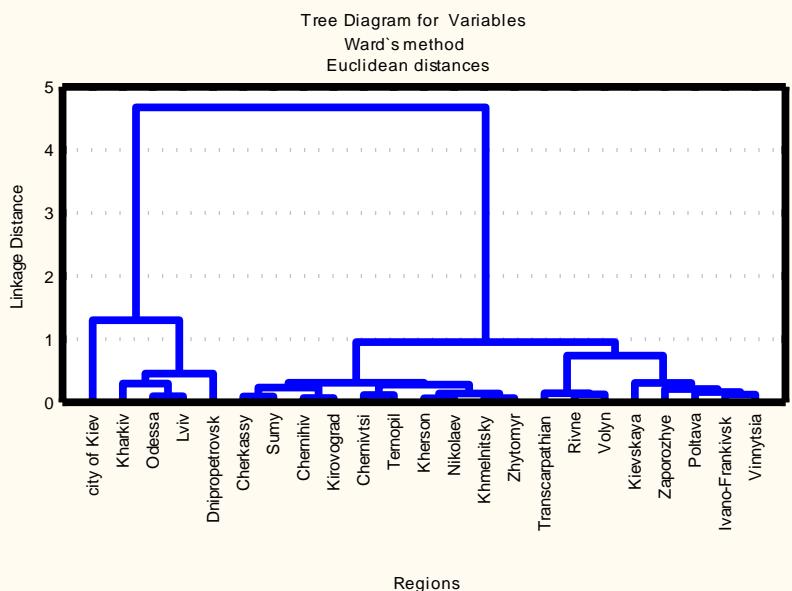


Figure 1. Dendrogram of splitting the regions of Ukraine into clusters according to the main demographic indicators over 2017

Source: compiled by authors grounding on data [19]

Thus, it is apparently the application of the cluster analysis method that has made it possible to identify the problems of human development common to all regions of Ukraine and to determine peculiar features which should be taken into account when developing measures aimed at the development of these regions. It is of paramount importance to take into consideration experience of the country with a set of similar conditions of development.

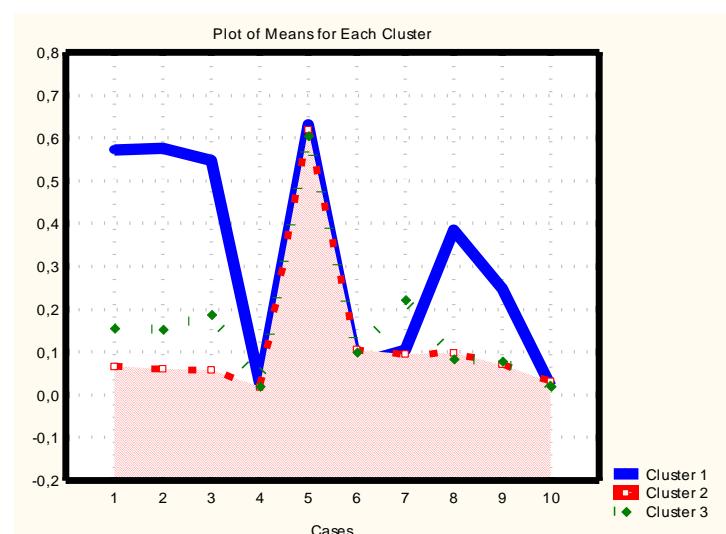


Figure 2. Clusterization of the regions of Ukraine by means of  $k$ -medium according to the main demographic indicators over 2017

Source: compiled by authors grounding on data [19]

## Notes:

1 - number of available population; 2 - number of permanent residents (estimated) at the age of 16-59 years;3 -number of live births;4 - average life expectancy at birth by gender;5 -economically active population aged 15-70;6 - unemployed population aged 15-70;7 - number of students of comprehensive educational institutions per 10,000 population;8 - number of students of higher educational institutions per 10000 population;9 - disposable income, per capita;10 - share of population with average total monthly income below the subsistence minimum.

In the opinion of the authors of this study, Ukraine position was due to the lack of clear strategies and programs of country's development, including demographic and social ones, for all years of its independence. "Strategy of economic transformations", "Strategy of economic and social development for 2000-2004 pp.", "Strategy of economic and social development of Ukraine for 2002-2011", "Main directions of social policy till the year 2004", Strategy of demographic development in the period up to 2015, the National Program "Health 2020: Ukrainian Dimension", the Strategy for Sustainable Development "Ukraine 2020", etc.were certain to be focused sufficiently on solving social and demographic problems within the framework of the projected positive economic changes in the country. But both the strategies and the programs aimed at their implementation did not provide for a clear demarcation of the spheres, indicators, ways of their achievement, performers, terms, as they acted mostly as an "instrument" for obtaining political power. Hardly had the government or the president changed the changes in the strategy took place. Moreover, carrying out the previous program, analysis of the problems that arose during its implementation, previous experience were considered unnecessaryand weren't taken into account by the "new government". Public reports including phased and systematic implementation of the above-mentioned strategies aren't available.

Nowadays, due to the orientation of Ukraine towards the European community, the situation regarding the development of a program of steps aimed at achieving strategic development goals is gradually changing for the better. Thus, the Draft Strategy of Sustainable Development of Ukraine until 2030 stipulates a significant orientation for solving social and demographic problems such as poverty reduction, starvation overcoming, good health and well-being, high quality education, gender equality, clean water and proper sanitary conditions, decent labor and economic growth, reduction of inequality. Essential tasks and their quantitative indicatorsare defined within each goal. However, a limited number of indicators and the scheduling the control reportson achieved results generally for a five-year period (2020, 2025, 2030) relieves the government of the responsibility for the Strategy's implementation at certain stages. It should also be mentioned that under the present conditions, the information component regarding the sectoral and territorial orientation of the Strategy of Ukraine Development, its degree of implementation is almost inaccessible. Data on the planned indicators of the Strategy and their implementation are either absent or presented episodically only and unavailable on the sites of the State Statistics Service of Ukraine, sectoral Ministries, regional councils.

Thus, the shortcomings in the development strategies and programs (including demographic one) of Ukraine, which are related to the availability of quantitative indicators and their details in terms of time, territorial and sectoral characteristics remain actual.

At the same time, the analysis of the Polish Strategies and Programs indicates an integrated approach both in planning and in reporting institutions involved in implementing the country's development strategy.

Currently, Poland development takes place within the framework of the Long-Term National Development Strategy "Poland 2030" (DSRK), an updated version of the Medium-Term National Development Strategy "Poland 2020" (NDS 2020). The development strategies of Poland are based on the principles of "Europe2020", "Europe 2030", taking into account national peculiarities and interests, with each of these strategies focusing on the development of human potential through the development of a separate sectoral strategy whose priority objectives are the development of human potential for the sake of giving every person opportunity to participate fully in social, political and economic life at all stages of his life.The National Policy for Development "Poland 2020" is detailed in the directions (areas) of implementation, in the territories (voivodeships), in terms of indicators and years, which enables transparency of control over the phased implementation of the planned activities. Furthermore, the sites of institutions, involved in the implementation of the country's development strategy, focus precisely on the content of the Program and the actual state of its implementation during the relevant period. The website of the Central Statistical Office of Poland contains detailed information on the planned and virtually achieved values of indicators as a general strategy of Poland development, as well as on its separate components in various directions and provinces.

Ukraine should continue to develop its demographic development program, taking into account both world

trends and positive experience of solving issues by closest neighbor - Poland, which, despite UN forecasts, managed to prevent population decline. This attainment, in turn, successfully ensured the country's economic growth and the development of its human capital.

In order to gradually bring Ukraine closer to the standard of living of the European community for achieving positive trends in demographic development (both quantitative and qualitative ones) it is worthwhile to take the following steps at the state levelin the nearest future:

- orientation of sustainable development of Ukraine on indicators of development of the EU countries;
- detailed comprehension of the Strategy of Sustainable Development of Ukraine (and, correspondingly, the program of actions) in the directions (branches), territories (regions) taking into account indices of regional human development of the regions of Ukraine and the results of clustering of its regions according to the basic demographic indicators;
- significant expansion of the range of indicators determining quantitative value within each component of the Strategy (program);
- systematic prompt reporting of authorities in charge of the implementation of each of the indicators;
- representing of planned tasks and actual reports on the site of the State Statistics Service of Ukraine, sites of sectoral Ministries, regional administrations and other institutions involved in the implementation of the Strategy (program);
- providing the data on the Strategies and Programs of Sustainable Development of Ukraine on the whole, as well as on individual componentsin the statistical reporting of the State Statistics Service of Ukraine;
- involving the wider public inshaping recmdendations, drawing conclusionsand evaluating the work of government agencies and services on implementing the Strategies and Programs of Sustainable Development of Ukraine as a whole, as well as on individual components and their availability for correction (if necessary);
- taking into account the experience of Poland in creating information environment to cover the actual state of achieving the goals of the Strategy for sustainable development of the country.

## **5. Conclusion**

According to the results of the study, the following conclusions can be shaped:

- application of an integrated approach to the analysis of demographic processes covering a wide range of demographic indicators gives opportunity to identify common (population structure, active migration processes, population over 65 years oldgrowth, etc.) and opposite (dynamics of the general population, natural population growth, unemployment rate and etc.) tendencies of the demography of Ukraine and Poland;
- it was established that under similar starting conditions of development in the 90s of the 20th century, current results of the development of the economic systems of Ukraine and Poland (per GDP per capita, IDI) are essentially different, which makes it next to impossible to put these countries at one stage of development;
- human factor is proved to be a strong component of the development of both countries (based on the results of the analysis of the dynamics of HDI, IDI);
- the proposed methodological approach to the assessment of the regional level of human development, based on the improvement of the mathematical tools for forecasting the vectors of the country's development, allows clusterizing the regions of the country for their demo-economic assessment;
- feasibility of using the proposed methodological support to assess the level of human development in the regions of Ukraineis justified, which makes it possible to systematize the common (unemployment and poverty of the population) and specific problems for the regions (development of the education system, income per person, etc.) of the population. It was determined that the first cluster includesthe most powerful and promising regions in terms of demographics (Dnipro, Lviv, Odesa, Kharkiv and Kyiv). The regions of the third cluster are not numerous ones, but have the potential to develop education. The second cluster grouped the largest number of regions of Ukraine, but the indicators are the worst in this cluster (Zhytomyr, Kirovograd, Mikolaev, Poltava, Sumy, Ternopil, Kherson, Khmelnytsky, Cherkasy, Chernivtsi, Chernihiv regions).
- basing on the use of a reasonable basis for inter-country comparison, it is proved that there are systemic deficiencies in the main software development documents of Ukraine and the organizational components of their implementation;
- established laws of demo-economic development of Ukraine in general and regional features in particular, the levers of state regulation of the formation of the human potential of Poland and monitoring of its results can serve as the basis of scientific and practical recommendations for the adjustment of the Strategy of

Sustainable Development of Ukraine.

Thus, the realization of the main scientific results of the research concerning the improvement of the mathematical tools of the analysis of demo-economic processes gives opportunity to deepen their diagnostics in order to clarify the vectors of the country's development and determine the complex of the corresponding tasks.

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