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DECISION SUPPORT SYSTEM IN ELECTRONIC DEMOGRAPHY

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Abstract. The article emphasizes the importance of a well-thought-out demographic policy for any state and lists the main tasks of demographic policy. The important role of demographic research is also noted. On their basis recommendations are developed for a more rational distribution of the population and improvement of its composition. The need for demographic research, as well as the penetration of information technologies into all spheres of human life and activities, led to the emergence of a new direction of demography – electronic demography (e-demography). In this regard, the article proposes an approach to the development of an electronic demographic decision support system using data warehouse (DW) technologies and interactive analytical processing OLAP. Thanks to these technologies, you can see the overall picture of demographic processes. This allows for high-level demographic research and supports demographic decision-makers. Because of the many types of demographics and the large number of indicators, the DW architecture is proposed as a data mart (DM) bus architecture with associated DM. This architecture consists of two levels: the first level is information from various e-government registers, the second level is DM. To implement the approach proposed in the article, an experimental e-demographic DSS was developed. It includes DW and OLAP. The DW architecture is a bus of interconnected DM. OLAP cubes are built on these DM. Their dimensions are indicators of the respective types of demographics. The system is implemented for personal computers running Windows 7, Windows 8, etc. The OLAP implementation environment includes an Excel Pivot Table, which is an OLAP visualization. The number of persons in different dimensions is determined by the COUNT aggregate function. The practical application of this approach is illustrated by the example of two DM. The first DM relates to descriptive demography and the second DM relates to geographic demography. OLAP cubes are built from these DM. OLAP operations let you view cubes in different slices. In conclusion, the importance of the electronic demographic system is shown, as well as the need for the development of this area in the future.

Key words: Demography, demographic policy, demographic behavior, electronic demography, Data Warehouse, OLAP, Data Mart, Data Mart Bus Architecture with Linked Dimensional Data Marts.

Introduction

Demography (ancient Greek δ□μος – people, ancient Greek γράφω – I write) studies the laws of population reproduction, the dependence of its character on socio-economic and natural conditions, migration. Demography as a science studies not only the size, territorial distribution and composition of the population, their changes, but also the causes and consequences of these changes.

Conducting a well-thought-out demographic policy is an important task for any state. The tasks of demographic policy include increasing the life expectancy of the population, reducing morbidity and mortality, increasing the birth rate, regulating both internal and external migration, maintaining and strengthening the health of the population, improving the qualitative characteristics of the population, providing state assistance to families with children, planning labor resources and etc., which are the basis for improving the demographic situation in a country [1]. Demographic research plays an important role in solving these problems. Based on their results, recommendations are developed that form the basis for demographic policy.

Today information technologies have penetrated into all spheres of human life and activity. They also influenced demographic behavior. As a result of this influence, a new area of demography, namely electronic demography (e-demography) has appeared, which occupies a special place among electronic institutions, such as e-government, e-science, e-education, e-medicine, etc. Research conducted in the field of e-demography has identified two main problems. On the one hand, this is the need to constantly provide more and more new sources of data and the possibility of using them for more thorough study of demographic processes, and on the other hand, it is the study of the impact of digital technologies on demographic behavior.

Technologies that can solve these problems include Data Warehouse (DW) and Online Analytical Processing (OLAP), involved in the electronic demographic decision support system (DSS). DW is a specially developed database with a large amount of information that is used for analysis and management decision-making. OLAP technology, in turn, is an element of DW and provides analysts with a general picture of the process flow, which allows improving the analytical component of the process. With OLAP, a user is given the opportunity to analyze data in real time, to make queries and receive reports. The use of the proposed technologies will ensure the preparation of a qualitatively new information layer in order to assist the decision-maker in the field of demography.

The article highlights the multi-layer nature of demography, as well as a list of indicators for each sector of demography. In addition, it proposes a model of DW in the form of interconnected Data Marts (DM), the measurements of which will be the proposed indicators. Moreover, it presents the use of OLAP technology based on this DW in the framework of e-demographic DSS.

E-demographic DSS with DW and OLAP technologies has broad capabilities for solving the assigned tasks: it provides prompt data processing, the issuance of ready-made reports in response to requests, the visualization of reports using tables and diagrams, etc.

Note that DW and OLAP technologies were successfully applied earlier by the author in the development of a terminological information system [2] in order to improve analytical activities and support decision-makers in the field of terminology, and a decision support system in the field of foreign policy [3] for study of the integration processes among countries. At the same time, the specificities of these areas were taken into account.

The main types of demography and their indicators

The object of demographic research is the population. Demographic studies include the quantity, territorial distribution and composition of the population, the patterns of their changes based on social, economic, biological, political, ethnic, geographical, military, historical and other factors [4].

In demography, the unit of the population is a person. The characteristics that a person possesses include: gender, age, marital status, education, occupation, nationality, place of residence, and so on. Obviously, many of these signs change over the course of life. A change in the life of each person leads to changes in the population as a whole. These changes as a whole constitute the movement of the population.

An important characteristic of demography is that it is an interdisciplinary field of research. In addition to population movement, demography also studies the dependence of the age distribution, national and ethnic composition, the geographical location of the population, its size, migration, the number of births and deaths on various factors, such as socio-economic, historical, political, ethnic, environmental, etc. In other words, demography examines the patterns of events and processes based on social, economic, historical, political, ethnic, environmental and other problems that arise in the structure, location, migration and dynamics of the population. Based on the above, demography is defined as an integrated science. Demography has established close ties with sciences such as economics, political science, ethnography, statistics, history, sociology, etc. (Fig. 1).

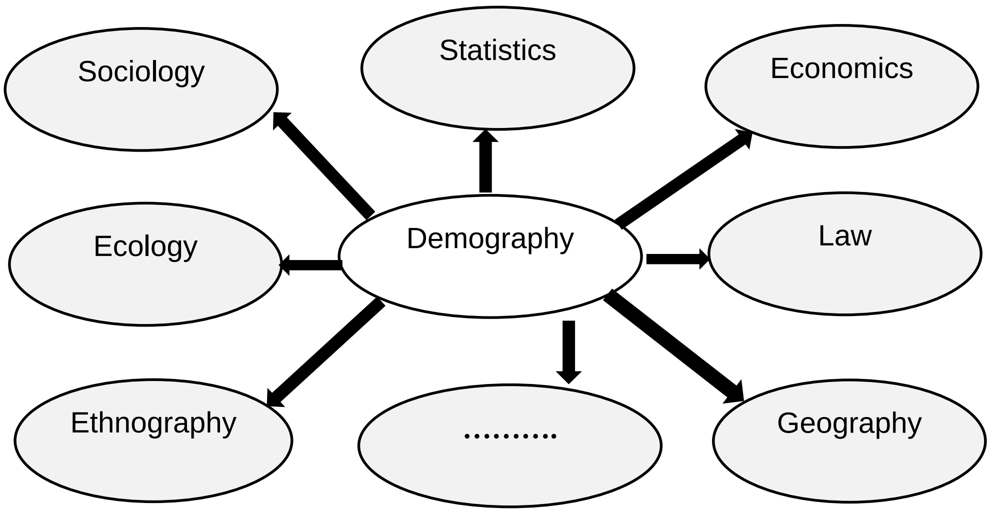

Fig 1. Relationship of demography with other sciences

As a result, it is divided into a number of specialized industries, each of which studies specific demographic processes.

Note that to build an e-demographic DSS using DW and OLAP, the dimensions of OLAP cubes have to be identified. In this case, industry indicators will serve as dimensions of OLAP cubes. Each of the demographic sectors has its own set of indicators. These industries are viewed with related indicators as follows:

- **Descriptive demography** characterizes the size and territorial distribution of the population, the level and trends of demographic processes in a particular country or region. The term also denotes general information about the size, composition, location and movement of the population of a particular country or territory [5]. Indicators of descriptive demography include the name, surname, patronymic of the person as a whole or his/her ID, gender, date of birth, marital status, type of activity, place of work, position, etc.
- **Demographic ecology or eco-demography** studies the impact of demographic processes on the prospects for the development of society and environment. Note that demographic processes are closely related not only to social processes, but also to environmental ones. The influence of the environment on reproduction processes is impossible without reference to environmental data [6]. In this regard, the indicators of eco-demography may include various indicators of the quality of life of the population, such as the levels of water and air pollution, the human development index, etc.
- **Economic demography** determines the relationship between economic and demographic processes, studies the features of the influence of the age-gender composition of the population and the components of natural reproduction of the population on the production process, the distribution of goods produced by society [7]. The indicators of economic demography include the indicators of descriptive demography, as well as economic

indicators such as gross domestic product (GDP), gross national income (GNI), GDP per capita, GNI per capita, average wages, etc. [8].

- **Ethno-demography** studies the ethnic composition of the population of different territories, the processes of change in the number of peoples of these territories, including the analysis of factors influencing it, the features of the natural reproduction of different ethnic groups [9]. The indicators of ethno-demography include the name of the territory, its ethnic composition, and all indicators of descriptive demography for each ethnic group.
- **Political demography** studies the demographic aspects of interethnic and social conflicts. The indicators of political demography include the military and mobilization potential of the state, the alignment of political forces due to emigration, “brain drain”, the number of different ethnic groups in top government posts, etc. [ten].
- **Geographic demography** unites a number of social sciences, primarily demography, economics and socio-economic geography. It studies the regional features of demographic processes, and the impact of both internal (demographic) and external (economic, settlement, social, ethnic, environmental, political) factors on them [11]. Since geographic demography analyzes the impact of the habitat on demographic processes, studies their territorial differences in dynamics, and also analyzes migration flows, its indicators include a set of indicators, namely: indicators of descriptive, economic, political demography, and ethno-demography.
- **Medical demography** studies the relationship of population reproduction with medical and social factors; and based on these data, the medical, social and organizational measures are developed, aimed at ensuring the most favorable development of demographic processes and improving the health of the population [12]. Medical and demographic indicators include the characteristics of the population’s health, the percentage of men and women in the total population of a given region, birth rate and mortality rates for different age groups, child mortality rates in different ages, morbidity rates indicating the names of diseases, the rate of natural increase or decrease in the population, infant mortality rate, etc.
- **Historical demography** studies the same processes and phenomena as demographic science as a whole, but in their historical retrospective [13]. Its indicators include all demographic indicators in their dynamics. Based on the data obtained, revealing the dependence of demographic characteristics on the level of historical development, on the characteristics of each historical stage makes it possible to generalize historical patterns.
- **Military demography** studies the mobilization capabilities of the state, human resources of potential military opponents and allies, population losses and migration processes caused by military operations, the impact of wars on the health and reproduction of population [14]. Consequently, its indicators include the indicators of the military power of a state, the losses among the military and civilian population presented in the gender-age aspect, which are directly related to military operations, and the number of morbidity and mortality indirectly related to military operations, the birth rate, the number of migrants during military actions, etc.
- **Social demography** studies the interaction of demographic and social processes [15]. This includes the study of the attitudes towards various demographic behaviors of individuals, social norms, demographic behavior and factors influencing it, which include education level, income, ethnic characteristics, etc. These factors can be attributed to the indicators of social demography.

As can be seen from the above, each of these types of demography has its own set of indicators that are viewed when analyzing demographic processes.

Formation of an e-demographic decision support system

To conduct an effective demographic policy, it is necessary to conduct research in the field of demography using modern information technologies, which form an e-demographic environment together with big data available in this area. The article [16] shows the need to develop an e-demographic system, and presents a list of important issues to be solved with its help. In addition, a conceptual model of the e-demographic system is presented.

To effectively solve the abovementioned tasks, it is required to develop a unified national e-demographic decision support system (DSS), which has the tools for data entry, storage and analysis related to the field of demography in order to make the right decisions. It is of great importance for ensuring the reproductive health of the population, improving the living conditions of the population, strengthening the family institution, solving migration processes, as well as for the development of human and scientific potential in the demographic sphere.

Note that due to the continuous increase in the volume of data in the field of demography, in addition to the data entry, the DSS, should also ensure their reliable storage. Data entry is provided by state data registries. In some cases, they can be OLTP-systems (Online Transaction Processing). Database Management System (DBMS) and Data Warehouses (DW) are used for data storage. DW can be presented in the form of Data Marts (DM).

OLAP (Online Analytical Processing) technology is capable to cope with the task of demographic data analysis and provides the information for decision-making. OLAP technology is an DW tool and uses its information. OLAP enables multidimensional data analysis by building cubes and provides opportunities for complex calculations, trend analysis and complex data modeling, planning, budgeting, forecasting, and more. The use of OLAP may significantly support decision makers (DM), and improve analytical activities in this area.

With OLAP technologies, multiparameter models are built, the purpose of which is to more adequately represent real processes. OLAP is based on concepts such as Hypercube or Metacube, Dimension, Members, Cell, Measure, Multidimensional Analysis, Data Marts. Typical OLAP Operations include slice & dice, roll-up and drill-down. Roll-up and drill-down operations, corresponding to the aggregation and disaggregation of data, are carried out on dimensions with hierarchical structure [17-18].

Since OLAP is an element of the DW, the priority is to develop the architecture of the DW. DW architecture depends on the characteristics and properties of the chosen sphere. When building the DW architecture of e-demographic DSS, its following characteristics should be taken into account:

- all types of demography will be included into the DW;
- each type of demography has a large number of indicators;
- some of the indicators are attributed to different types of demographics

Due to the presence of several types (industries) of demography, a large number of indicators ensures that for this system, Bus Architecture with Linked Dimensional Data Marts is chosen as the architecture of the DW [19].

DM is specialized storage facilities serving one of the areas of activity. The emergence of DM was an attempt to soften the requirements for DW. Each DM includes data aimed at solving a separate problem.

Table 1 summarizes the main differences between DW and DM.

Table 1. Differences between DW and DM

Category	DW	DM
Volume	Corporate	Separate functional area
Task	Multiple	One
Data sources	Many	Few
Size (usual)	From 100 GB to 1TB and more	<100 GB
Implementation time	From several months to several years	A few months

The size and complexity of the DM structure, which also support decision making, are unlimited. However, they tend to be smaller and less complex than DWs. Thus, they tend to be easier to create and maintain. DMs are the data arrays focused on one functional area and represent a simple form of DW. As the DW, with an analytical tool such as OLAP, the data is analyzed, trends are identified, future results are predicted, etc.

The proposed architecture for e-demographic DSS consists of two layers presented in Figure 2. The first level includes data sources. They represent information from government registries or OLTP systems. The second level includes directly the DMs themselves.

In the current task, DMs are focused on the analysis of separate sectors of demography. The representation of each branch of demography in the electronic demographic system requires the inclusion of the relevant indicators into the DM of this branch as the dimensions.

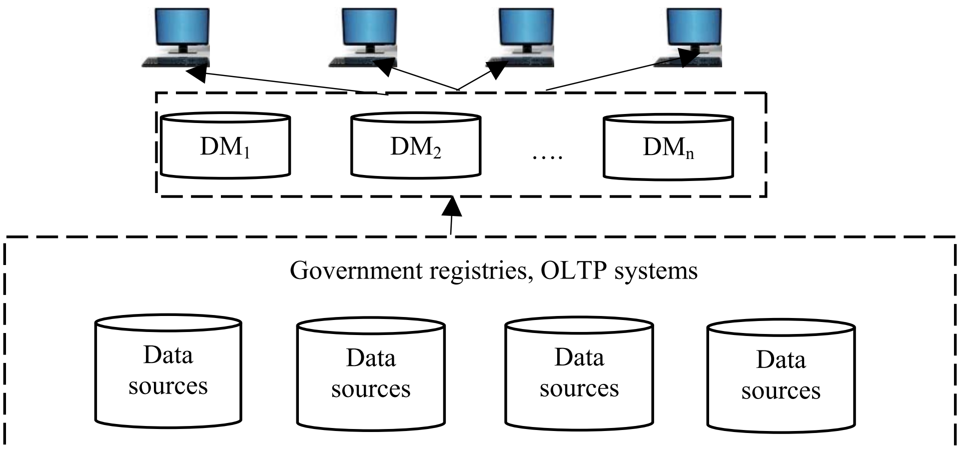

Fig. 2. DW architecture for e-demographic DSS.

For example, “Descriptive demography” corresponds to the DM with dimensions related to the structure of the population: last name, first name, patronymic of the person or ID, gender, date of birth, place of residence, marital status, etc.; “Economic demography” includes various economic indicators for the analysis of demographic processes against their background; “Military demography” includes the indicators of the military power of the state, military losses of the population in the sex-age aspect, the number of migrants during hostilities, etc.

Within the framework of the system, an OLAP cube is built based on each DM. A set of OLAP cubes forms a polycubic model. The polycubic model included into the e-demographic DSS is presented in Figure 3.

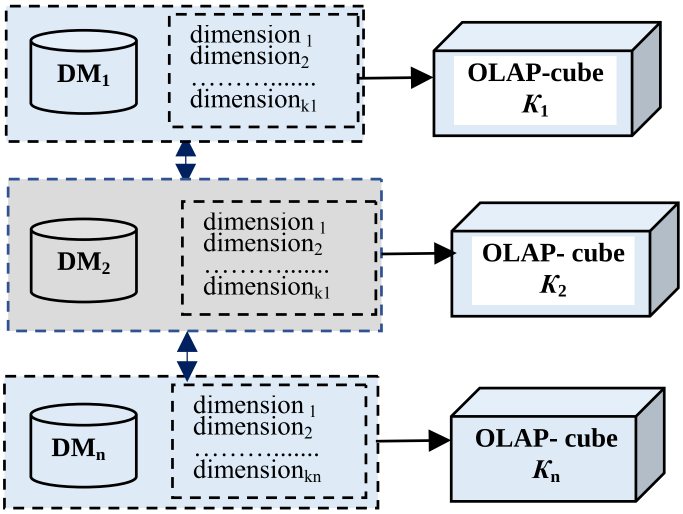

Fig 3. Polycubic OLAP-model included into the e-demographic DSS.

The creation of a DM begins with an analysis of the requirements for the demographic industries. The first DM is built for the demographic industry, using dimensions, as well as the indicators that will be further applied in other demographic sectors. This branch of demography is the descriptive demography. Subsequent DMs are developed using these dimensions, as well as the dimensions for specific to certain industry. As a result, such a system architecture leads to the creation of logically integrated DMs.

Practical use

To implement the approach proposed in the article, an e-demographic DSS is developed, which includes DW and OLAP. The DW architecture is a bus architecture with Linked Dimensional DMs. As noted above, OLAP cubes are built on these DMs, the dimensions of which are the indicators of the corresponding types of demography.

The system is implemented for personal computers running Windows 7, Windows 8, etc. The OLAP implementation environment includes an Excel Pivot Table, which is an OLAP visualization. The number of persons in different dimensions is determined by the aggregate function COUNT.

This system model includes two DMs as an example. Both DMs include the data on the representatives of the scientific community of Azerbaijan, namely, on the employees (PhDs) of randomly selected institutes of the National Academy of Sciences of Azerbaijan and higher educational institutions of Azerbaijan.

The dimensions of the OLAP cube built on the first DM include last name, first name, patronymic, date of birth, sex, place of birth, place of work, position, marital status, number of children in the family, etc. of employees. In other words, this may include descriptive data about employees. Therefore, this DM can be attributed to descriptive demography.

Figure 4 shows an example of a cube slice obtained as a result of a request:

How many employees in the selected organizations are there and how many of them are unmarried? The analysis is conducted for 2018 and 2019.

As seen from the figure, out of 202 employees of the selected organizations in 2019 compared to 2018, the number of married employees increased from 176 to 194.

The second DM is based on data about scientists emigrated from Azerbaijan.

The dimensions of the OLAP cube built on the second DM include name, date of birth, gender, place of birth, country of migration, reason for migration, economic and political situation in the country where the employee migrated to, place of work, field of activity, position, number of years of stay in that country, marital status, etc. In other words, this includes descriptive data on staff, as well as the data on the country of migration. Therefore, this DM can be attributed to geographic demography, which demonstrates migration flows.

Figure 5 shows an example of a cube slice obtained as a result of a request:

How many scientists and to which country have emigrated from Azerbaijan (for example, to 5 countries – the USA, Germany, Russia, Turkey, Ukraine), indicating the period of stay in this country.

Here, as it is seen, aggregate data for the countries are presented without breakdown by specialty, indicating the period of stay in the country.

Name of lines	married	not married	
2018	176	26	202
Sheki branch of ASPU	1		1
Ganja Branch of ANAS, Institute of Ecology and natural resources	1		1
Institute of Control Systems of ANAS	13		13
Institute of Information Technology of ANAS	15	2	17
Nakhchivan Branch of ANAS, Institute of Art, Language and Literature	3	1	4
Nakhchivan Branch of ANAS, Institute of Bioresources	18	1	19
Nakhchivan Branch of ANAS, Fund of Manuscripts	1		1
Nakhchivan Branch of ANAS, Institute of History, Ethnography and Archaeology	9		9
Nakhchivan Branch of ANAS, Institute of Natural Resources	5	2	7
Institute of Radiation Problems of ANAS	3		3
Institute of Mathematics and Mechanics of ANAS	32	3	35
Institute of Physics of ANAS	54	17	71
Lankaran Regional Scientific Center of ANAS	1		1
Sheki Regional Scientific Center of ANAS	9		9
ASOIU	1		1
ADPU	1		1
Azerbaijan University of Cooperation	2		2
Azerbaijan Technical University	1		1
Baku State University	5		5
National Aviation Academy of Azerbaijan	1		1
2019	194	8	202
Sheki branch of ASPU	1		1
Ganja Branch of ANAS, Institute of Ecology and natural resources	1		1
Institute of Control Systems of ANAS	13		13
Institute of Information Technology of ANAS	15	2	17
Nakhchivan Branch of ANAS, Institute of Art, Language and Literature	4		4
Nakhchivan Branch of ANAS, Institute of Bioresources	19		19
Nakhchivan Branch of ANAS, Fund of Manuscripts	1		1
Nakhchivan Branch of ANAS, Institute of History, Ethnography and Archaeology	9		9
Nakhchivan Branch of ANAS, Institute of Natural Resources	7		7
Institute of Radiation Problems of ANAS	3		3

Fig. 4. Number of employees, married and unmarried (for 2018 and 2019).

Name of lines / Length of residence (in years)	4	5	7	8	9	10	12	13	16	17	18	19	20	Total
USA							2		1	1				4
Russia	1	1												2
Germany		1	1	1	1	1					1	2	1	9
Turkey		1	1	1	1	1					1	2	1	9
Ukraine			1	1				1						3
Total	1	3	3	3	2	2	2	1	1	1	2	4	2	27

Fig. 5. The number of scientists who emigrated abroad, indicating the period of stay in that country (for example, 5 countries of the United States, Germany, Russia, Turkey, Ukraine).

Figure 6 shows a cube slice obtained as a result of the request:

How many scientists, to which country and in what specialty have emigrated from Azerbaijan (for example, to 5 countries - USA, Germany, Russia, Turkey, Ukraine), indicating the period of stay in that country.

Name of lines / Length of residence (in years)	4	5	7	8	9	10	12	13	16	17	18	19	20	Total
USA							2		1	1				4
Mechanics							1							1
Maths							1			1				2
Medical sciences									1					1
Russia	1	1												2
Agricultural sciences	1	1												2
Germany		1	1	1	1	1					1	2	1	9
Physics					1	1					1	1		4
Mechanics													1	1
Maths				1								1		2
Turkey		1	1	1	1	1					1	2	1	9
Biological sciences		1												1
Physics					1	1					1	1		4
Mechanics													1	1
Maths				1								1		2
Technical science			1											1
Ukraine			1	1				1						3
Biological sciences			1	1										2
Maths								1						1
Total	1	3	3	3	2	2	2	1	1	1	2	4	2	27

Fig. 6. The number of emigrated scientists with an indication of specialties (for example, to the USA, Germany, Russia, Turkey, and Ukraine).

Thus, viewing the first country, namely the USA, it is concluded that: 4 people emigrated to the USA from the selected organizations of Azerbaijan. One with a scientific degree in Mechanics and has been living there for 12 years; two with a scientific degree in Mathematics, one of them has been living there for 12 years and another for 17; one with a scientific degree in Medical Sciences and has been living there for 16 years.

In these examples, a small number of dimensions are selected. However, the capabilities of this system are wide enough. They depend on the fullness of the DW. OLAP cubes allow exploring demographic processes in different slices depending on the request, and also provide aggregate data.

Conclusion

A balanced, effective demographic policy is an integral part of the e-government system. To implement it, it is necessary to develop systems for assessing, analyzing and making the right decisions in the existing demographic situation, using various state registries. Along with traditional factors, such as migration, birth, death, the demographic processes are also affected by various socio-economic situations, characteristics of the population's health, various indicators of the quality of life of the population, military operations, ethnic composition, natural disasters, etc. In this regard, the presence of various types of demography complicates the analysis of demographic processes in the traditional way.

This article showed the feasibility and effectiveness of using e-demographic DSS for the implementation of demographic policy with DW and OLAP included in it. Thanks to these technologies, you can see the overall picture of demographic processes. This allows for high-level demographic research and supports demographic decision-makers.

Because of the many types of demographics and the large number of indicators, the DW architecture is proposed as a data mart (DM) bus architecture with associated DM. DM also supports decision making. However, they are smaller and less complex than DW. Thus, they are easier to create and maintain. In DM, just like in DW, using an analytical tool like OLAP, data is analyzed, trends are identified, future results are predicted, etc.

To implement the approach proposed in the article, an experimental e-demographic DSS was developed. It includes DW and OLAP. The DW architecture is a bus of interconnected DM. OLAP cubes are built on these DM. The OLAP implementation environment includes an Excel Pivot Table, which is an OLAP visualization. The practical application of this approach is illustrated by the example of two DM. The number of persons in different dimensions is determined by the COUNT aggregate function.

The proposed e-demographic DSS may ensure further online monitoring, analyze demographic processes based on the available data, and identify problems associated with demography. In addition, the e-demographic DSS will be used to achieve goals in forecasting human resources, will help determine the strategic trends of future economic and social development, thereby contributing to an increase in the number and quality of the working population.

Given the relevance of the topic, the issues related to analysis and forecasting will be considered in further research.

References

1. Rudnitskaya A., Novikov E. The main directions of formation, problems and tasks of demographic policy in modern Russia. *PolitBook*. 2015. 1. P. 43–56. (in Russian). Available from: https://cyberleninka.ru/article/n/osnovnye-napravleniya-formirovaniya- problemy-i-zadachi-demograficheskoy-politiki-v-sovremennoy-rossii.
2. Alguliyev R., Nabibayova G., Gurbanova A. Development of a Decision Support System with the use of OLAP-Technologies in the National Terminological Information Environment. *International Journal of Modern Education and Computer Science (IJMECS)*. 2019. V. 11, 6. P. 43–52.
3. Nabibayova G. Application of OLAP-technologies in decision support systems in the field of foreign policy. *Information Technology*. 2012. 2. P. 73–76. Moscow: Noviye tekhnologii. (in Russian).
4. Levina E. The history of demography as a science and its role in the current macroeconomic situation in Russia. *Bulletin of TSU*. 2008. 11 (67). P. 409–413. (in Russian). Available from: https://cyberleninka.ru/article/n/istoriya-demografii-kak-nauki-i-ee-rol-v-sovremennoy-makroekonomicheskoy-situatsii-v-rossii.
5. Valentey D. I. (ed). *Descriptive Demography*. *Encyclopedic Demographic Dictionary*. Moscow: Sovetskaya entsiklopediya. 2015 (in Russian).
6. Knowledge Fund "LOMONOSOV". (2010). *Demography*. [Online] October 2010 (in Russian). Available from: http://www.lomonosov-fund.ru/enc/ru/encyclopedia:0147:article?vnum=28696 [Accessed: 31th January 2020].
7. Boyko A., Karmanov M. *Economic demography*. Moscow: Publishing house of MESI. 1999. 68 p. (in Russian).
8. Mohnatkina E., Golubev A. Indicators, trends and factors of economic development of economic entities in the Russian Federation. *Scientific journal NRU ITMO. Series "Economics and Ecological Management"*. 2015. 3. P. 106–116. (in Russian).
9. Kasmina O., Puchkov P. *Basics of Ethnodemography*. Moscow: Nauka. 1994. 253 p. (in Russian).
10. Sakayev V. Political demography: subject field and research opportunities. *The scientific and political journal "Vlast", Institute of Sociology, Russian Academy of Sciences*. 2011. 7. P. 86–88. (in Russian).
11. Fedorov G. On current trends in geodemographic research in Russia. *Baltic region*. 2014. 2 (20). p. 7-28. (in Russian).
12. Sharshakova T., Dorofeev M. *Population statistics and medical demography*. Gomel: GSMU. 2014. 57 p. (in Russian).
13. Motrevich V. *Historical demography of Russia*. Ekaterinburg: Publishing house of the Ural Federal University. 2000.168 p. (in Russian).
14. Vorontsov A. *Demography*. 2016 [Online] (in Russian). Available from: URL: https://studme.org/44089/sotsiologiya/demografiya [Accessed: 10th January 2020]
15. Belyaevsky I. *Social and demographic marketing: problems, goals, analysis.* 2014 [Online] (in Russian). Available from: http://library.asue.am/open/art27.pdf [Accessed: 14th January 2020]
16. Alguliyev R., Aliguliyev R., Yusifov F., Alekperova I. Developing electronic demography as an effective tool for social research and

monitoring population data. *Public administration issues.* 2020. 4. P. 61–86. (in Russian). Available from: https://vgmu.hse.ru/2019--4/326123454.html
17. Zabotnev M. *Methods of presenting information in sparse data hypercubes.* 2006 (in Russian). Available from: http://www.olap.ru/basic/theory.asp (in Russian). [Accessed: 16th Oktober 2019].
18. Kashirin I., Semchenkov S. Interactive analytical data processing in modern OLAP systems. *Business Informatics*. 2009. 2. P. 12–19. (in Russian).
19. Ariyachandra T., Watson H. Key Factors in Selecting a Data Warehouse Architecture. *Business Intelligence Journal.* 2005. vol. 10. 2. P. 19–26.

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