

The use of SMART technologies in censuses: world experience and prospects for Ukraine

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Received: 30.05.2020 Received in revised form: 19.06.2020 Accepted: 25.12.2020 **Abstract.** Current records of the population in Ukraine are carried out systematically by the relevant bodies and departments of statistics of various levels. It provides an opportunity to quickly obtain the main statistical characteristics of the population in a short time. However, other important parameters of the country's population, such as ethnic structure, literacy,

education, property status and other important indicators, do not take this into account. They can only be installed by census. The article analyzes the results of censuses of some countries of the world, which decided to introduce innovative technologies - SMART-phones, Internet resources - into this process. The study revealed the advantages and disadvantages of such a census format. In the course of the scientific research, statistical indicators of censuses using innovative technologies, which were conducted in the respective years in the USA, Canada, Lithuania, Estonia, Brazil, Australia were analyzed. The basic normative provisions concerning the census procedure in Ukraine, covered in the main legislative documents, as well as the materials of the Institute of Demography and Social Research named after M. V. Ptukha of the National Academy of Sciences of Ukraine, which develops the program and questionnaire of censuses in our country. SWOT analysis of the use of SMART technologies in the census was conducted to identify the advantages and disadvantages, as well as to outline the prospects and threats of the census using innovative technologies. Benefits include the ability to quickly collect and organize information, low census costs, compared to the traditional option. The main disadvantages of the latest census should be mantioned the need to develop expensive software with a high degree of personal data protection, as well as the complexity of fully transitioning the census to the online platform. Studying the experience of countries that have already conducted population censuses using innovative technologies indicates the importance of legally binding participation in the census questionnaire (either electronically or traditionally). The possibility of conducting two stages of population census in Ukraine in 2020 is indicated: in the online mode and in the traditional format. Such an approach to the census procedure will allow the coverage of respondents in all regions and settlements of Ukraine.

Keywords: census, innovative technologies, statistics, population geography, demogeography

Застосування SMART-технологій під час переписів населення: світовий досвід і перспективи для України

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Анотація. Поточний облік населення в Україні здійснюється систематично відповідними органами та управліннями статистики різного рівня. Він дає можливість оперативно отримати головні статистичні характеристики населення країни у стислий термін. Однак інші важливі параметри населення країни, зокрема, етнічну структуру, рівень грамотності, рівень освіти, майновий стан та інші важливі показники такий облік не враховує. Їх можна встановити лише шляхом перепису населення. В статті проаналізовано результати переписів населення окремих країн світу, які наважились на впровадження в цей процес інноваційних технологій – SMART-телефонів, інтернет-ресурсів. Дослідження дало можливість виявити переваги і недоліки такого формату перепису населення. Під час наукового дослідження було проаналізовано статистичні показники переписів населення було проаналізовано статистичні показники переписів населення. Бастонії, Бразилії, Австралії. Вивчено основні нормативні положення, які стосуються процедури переписів населення в Україні, що висвітлені в основних законодавчих документах, а також опрацьовано матеріали Інституту демографії та

соціальних досліджень ім. М. В. Птухи Національної Академії Наук України, який розробляє програму та анкету переписів населення в нашій країні. Для виявлення переваг та недоліків, а також окреслення перспектив та загроз перепису населення з використанням інноваційних технологій, було здійснено SWOT-аналіз застосування SMART-технологій під час перепису населення. Серед переваг: можливість швидко зібрати і систематизувати інформацію, низькі затрати на проведення перепису, порівняно із традиційним варіантом. Основними недоліками новітнього перепису варто вказати необхідність розробки дорогого програмного забезпечення із високим ступенем захисту персональних даних, а також складність повного переходу перепису населення на он-лайн-платформу. Вивчення досвіду країн, які вже проводили переписи населення із застосуванням інноваційних технологій, вказує на важливість закріплення на законодавчому рівні обов'язкової участі у процедурі опитування під час перепису (у електронному або традиційному вигляді). Вказано на можливості проведення двох етапів перепису населення в Україні у 2020 році: у он-лайн режимі та традиційному форматі. Такий підхід до процедури перепису дозволить охопити респондентів в усіх регіонах і населених пунктах України.

Ключові слова: перепис населення, інноваційні технології, статистика, географія населення, демогеографія

Introduction.

One form of population accounting and survey is census, which, according to recommendations of the United Nations since 1961, is conducted every 10 years in each country of the world. The censuses make it possible to visualize the basic parameters of the population (number, sex and age structure, national composition, level of education, literacy, property status, income level, etc.) and to identify trends of further development of a society of a country, to distinguish the main problems and disparities.

The first population censuses in the world began to take place as early as 4.5-5 thousand years BC in the territory of Ancient India, China, Sumer. And the first modern-day census was conducted relatively recently – in 1846 in Belgium. Its program has become the basis for all modern population censuses in the world.

Modern technologies, such as Internet resources, make it possible to streamline and accelerate the process of collecting and processing statistics during censuses. In addition, as shown by the practice of countries that have already tested SMART technologies in conducting the census, this process can significantly save the money allocated for the census procedure, to conduct it quickly and efficiently. In 2020, it was planned to be held in Ukraine, during which partial use of SMART technologies is planned. Therefore, it is important to analyze all the advantages and disadvantages of the newest technologies that will be applied, comparing with the foreign experience.

Materials and methods of research.

The research used statistical indexes of censuses which used innovative technologies that were conducted in the United States, Canada, Lithuania, Estonia, Brazil, Australia in the relevant years. The SWOT analysis was used to analyze the advantages and disadvantages, as well as the prospects and threats of conducting a census using SMART technologies. The basic normative provisions concerning the census procedure in Ukraine, covered in the main legislative documents, were studied: the Law of Ukraine "On All-Ukrainian Population Census" (Adoption on October 19, 2000, No. 2058-III, Verkhovna Rada of Ukraine), 2000, No. 51-52, Art. 446) 4.; <u>the</u> Regulation "On the State Statistics Service of Ukraine", approved by the Decree of the Cabinet of Ministers of Ukraine on 23.09.2014, No. 481, as amended, approved by the Decree of the Cabinet of Ministers of Ukraine Decree on 10.12.2019, No. 1072; the Standard Law "On Official Statistics" (developed within the framework of the project of ninth tranche "Accounts of the development of the United Nations (UNDS) for Eastern Europe, Caucasus and Central Asia" (approved by the Conference of European Statisticians, 27–29 April, 2016).

Along with the collection, processing and publication of census results, as well as the current census, there is a need to preserve a large array of statistical information in digital form, to counteract the "leakage" of personal data of citizens. And this creates a number of new challenges for scientists in countries that plan to record the population using innovative technologies. These pressing issues are reflected in the research of modern scientists who consider the use of new technologies for creation of large databases that include huge amounts of statistical information (Chatfield, Ojo, Puron-Cid, Reddick, 2018), explore the application of SMART-technologies for statistical surveys of the cities (Bação, Henriques, Antunes, 2018) and for the current population accounting for the conditions where the census is impossible (Wardrop, Jochem, Bird, Chamberlain, Clarke, Kerr, Bengtsson, Juran, Seaman, Tatem, 2018).

To study the indicators of the First All-Ukrainian Population Census of 2001, as well as to identify the main shortcomings of its conducting, the data from the official website of the State Statistics Service of Ukraine (Official page of the First All-Ukrainian Population Census of 2001 - https://www.ukrcensus. gov.ua/eng/) notice / news.php) has been studied. To get acquainted with the historical aspects of censuses on the territory of Ukraine and in the world, as well as current trends and possibilities of demographic population survey, the scientific achievements of foreign and Ukrainian scientists – geographers, demographers and economists were studied, such as: O. Grishnova, I. Kalachova, I. Kurilo, E. Libanova, L. Lisogor, V. Steshenko, L. Tkachenko and others; the materials of the Institute of Demography and Social Research named after M. V. Ptukha of the National Academy of Sciences of Ukraine were processed.

Results and their analysis.

Censuses in the countries of the world have always been carried out by means of questionnaire survey. The development of modern information technologies makes it possible to digitize such questionnaires and to conduct surveys online or using e-mail. For the first time, innovative technologies for population census applications have been applied in the United States and have shown good performance.

With the development of the Internet and its accessibility in most regions of the world, every

resident can now, without any problem, at any onvenient time to send his data directly to the service or statistics department in their country.

One of the typical features of the introduction of SMART-technologies in the process of population census is the leveling of differences in socioeconomic development of different countries of the world. This is confirmed by the fact that the first population censuses via the Internet were conducted in economically highly developed countries – the USA, Canada and Australia. Subsequently, these forms of population accounting began to spread rapidly in other countries, and became especially popular in the group of countries with medium economic development – Brazil, Lithuania, Bulgaria and others.

Canada was the innovator in censuses and the first country to use SMART technologies. The first census using the electronic form was conducted here in 2006. Failure to participate in the census imposed a fine or threatened imprisonment. And already in 2011, participation in the census was voluntary for every inhabitant of the country and provided:

- passing a traditional survey using a paper census questionnaire (filling out a paper form). In this

 Table 1. Use of SMART technologies duting census in some countries of the world

Country	Year of the census	Population at the time of the census, million people	Share of population surveyed using SMART technologies,%	Census cost per capita, in USD	Census tools and means of identifying the persons who participated in the census
USA	2010	308. 75	-	47	Submission of data into electronic census forms by instructors
Brazil	2010	190. 75	100	4.8	LG 750GM Smart Phones, Special Software
Canada	2011	33. 48	54	17.4	Website www.census2011. gc.ca, e-questionnaire, personal access number provided by e-mail, call to the call center by the "green number"
Australia	2011	22.34	10.2	19.0	Website www.abs.gov.au, e-questionnaire, e-number
Bulgaria	2011	7.37	41	4.3	Email, Information System Module "Census"
Lithuania	2011	3.05	34	3.8	Website www.esurasymas. lt, e-questionnaire, personal citizen number, internet banking or ID-card
Estonia	2012	1.34	63	19.0	Website www.rel2011.ee, e-questionnaire, ID-card, Mobil-ID, internet banking passwords Swedbank, SEB (U Net), Sampo

case, each resident of the countries received from the statistics department an envelope with forms, which had to be filled and sent within the specified time. Each package had an extra envelope that filled in the forms and was sent to the Statistical Office address (the envelope already contained a sticker indicating the return address). Each resident was given his or her unique ID of the survey participant;

- filling in an electronic form on the relevant website of the statistics service.

Conducting the survey appropriately made it possible to optimize the costs of conducting the census procedure – only 15.2. USD per capita.

In 2010, the United States first used SMART technologies when conducting a census. In addition, more than 65.000 instructors have been recruited to perform the census in the traditional way. By the way, in the US, the census procedure is mandatory for every resident, and evasion of it implies a fine of 100 USD. False information filing – 500 USD.

The census in the United States involved several stages – the formation of a single population base for the country, for which a properly trained instructor had to go around every home, every home and record all the people who live there. In the future, this information was used for rescue, social security, Google map optimization and more.

Despite the clear and deliberate organization of the census and the use of the latest technologies to conduct it, only 70% of the country's population participated in the 2010 U.S. Census. The introduction of information technology to collect data during censuses has revealed not only the positives, but also a number of disadvantages, including the unreliability of the system and the storage of individual data. Therefore, in addition to the online census, the United States retains the traditional census form.

Of the European countries, Lithuania (2011) was the first to decide to use SMART technologies for the census procedure. At that time, 34% of the country's population (1.039 million people) were polled. The small number of respondents who took part in the electronic survey was caused by a number of important problems with the Lithuanian population census (Marcu, 2011) :

- low proportion of people using Internet resources (less than 60%);
- the electronic questionnaire was created only in Lithuanian;
- the obligation to pass the population census has not been approved at the legislative level.

Thus, the majority of the Lithuanian population

still underwent the census procedure according to the classical scheme – answering the questions of the volunteer-interviewers.

Among the main advantages of online census in Lithuania:

- significant cost savings (out of the 10 million lats allocated for the census procedure, only 6 million was spent due to the reduction of the amount of human resources involved in the work);
- the ability of one person to fill in the questionnaires of all his or her family members living with him / her;
- reducing the number of classic Eurostat questionnaires by more than twice.

An online population census conducted in 2011 in Bulgaria has shown significant benefits. The advanced form and timeliness of the procedure enabled it to become one of the most successful first censuses in the world using innovative technologies. It allowed to cover 42% of the country's population. An e-mail was sent to each resident for the census, allowing them to access their office at the census site. In addition, 46.000 instructors were recruited to perform the census in the usual manner.

Modern information and communication technologies have been successfully used in Estonia in the 2012 census. The disadvantages of the censuses of Lithuania and Bulgaria were taken into account, which made it possible to interview more than 63% of the population of the country and to collect accurate statistical information.

The main advantages of online census in Estonia:

- respondents were interviewed using questionnaires developed in English, Russian and Estonian;
- the necessity of passing the census was fixed at the legislative level and a fine of 2 thousand EUR was provided for a failure to comply with this resolution;
- a powerful arsenal of digital tools (ID-cards, Internet banking, Mobil-ID, etc.) was used to identify the persons who were undergoing the census and to keep their private information;
- in addition to the Internet census, there was a traditional survey of people using laptops.
- this census organization reduced the cost of the procedure to 19 USD per capita.

Brazil is the first country to conduct an electronic census of the population, completely abandoning traditional paper. Brazil's experience with the use of the latest census tools and methods is most successful. In the short term it was possible to:

- accurately determine the residence of each

Brazilian family (through the use of GPS technologies);

- conduct population surveys in all regions of Brazil. This is a great achievement, especially given the fact that individual sections are difficult to access due to the complexity of the terrain;
- get accurate information on all the questions provided in the survey form;
- reduce the time for statistics to be processed from several years to several months;
- minimize the cost of the census procedure 4.7 USD was spent for each census resident.

To organize and conduct the census in Brazil, 150.000 smartphones were purchased and a special census program was installed on them. All data

from each smartphone was transmitted to one of the 7.000 static data centers hosted nationwide by GPS navigation.

Analyzing the peculiarities of the use of SMARTtechnologies in conducting modern censuses, we can note that in different countries the latest survey tools and methods were used:

- survey via the Internet;
- email survey;
- smartphone survey.

SWOT analysis is one of the most effective tools of socio-geographical research that allows to study the phenomenon from different perspectives – to outline the advantages, highlight the disadvantages, formulate prospects and threats in its development.

Advantages	Disadvantages	
- the ability to gather quickly relevant statistical information and transfer it to statistical centers;	- requires the development of special software;	
noduction of time for an coording statistical information.	- a lengthy procedure of preparing for this type of census,	
- reduction of time for processing statistical information;	- the need to check constantly the system software;	
have to directly contact people who belong to the marginal sections of society);	- training of specialists who will receive and process statistical information is required;	
- total coverage of all residents in the survey during the census, regardless of the territory of residence, employment	- lack of accessibility of the Internet for all residents of the country;	
 and other reasons that hinder the census procedure; an opportunity to receive complete information that will reflect the real indicators of the population in general, the share of pensioners, the real level of income of the negative determined by the effective of the effective for the effective for the effective of the effecti	- there is a problem of ensuring the confidentiality of the data of the census participants (they can be easily intercepted on the way from the participant's computer to the statistical service server);	
implementation of national and regional social policy;	- the need to develop complex cryptographic programs;	
- 2 times less staff will be involved in conducting the census procedure:	- inability to identify the data subject;	
- the respondent can take the survey at his or her convenient time by registering on the census site;	- the need to conduct a traditional census with the involvement of volunteer instructors alongside the Interne census, since many people (elderly, children or disabled will not always he able to gene with the latent technologies	
- one household representative can fill in the details of all his / her members;	or simply do not have access to the Internet because of their low income;	
- anonymity of the survey during the census;	- the inability to conduct an online census in mountainous areas where there is no connection.	
- significant savings of the state budget funds.		
Threats	Prospects	
 there is a risk of providing inaccurate information that is difficult to verify, especially when one household member fills in a form for each person who is a household member; "leakage" of personal data due to defects and malfunctions of the system or network is possible; 	 - a significant reduction in the cost of the census compared to the traditional option; - census of the Ukrainian population with the use of SMART-technologies requires certain innovations at the legislative level. 	
- the problem of inclusion in the census of children studying abroad.		

Table 2. SWOT-analysis of the use of SMART-technologies during the census

By conducting a SWOT analysis of the use of SMART technologies during the census in Ukraine, we can conclude that such a census will have far more advantages than disadvantages. Its main positive points will be, then, as follows:

- saving of public funds allocated for the census procedure (and this is especially relevant for Ukraine, whose economy is in crisis);
- anonymity of the survey for the first time in the census history of our country a special procedure of encryption of the data of the respondents will be applied with their corresponding registration number;
- the ability to conduct a population census procedure quickly and to survey all regions of Ukraine, as well as to process statistical data in a short time, etc.

The main disadvantages of the latest census should be the need to develop expensive software with a high degree of personal data protection, as well as the complexity of fully transitioning the census to the online platform. However, despite the high level of technological ability of Ukrainian society, access to the Internet is not available throughout Ukraine. Particular difficulties with the Internet census can occur in rural areas of Chernihiv, Zhytomyr, Sumy regions, where there are large number of villages with a population of up to 50 people, mostly elderly people. The young people left these territories to study and work in the cities, so there is no need to talk about the latest technologies.

The task for the Cabinet of Ministers in the near future should be to develop a legislative framework for responsible population participation in the census.

Discussion.

Conducting the First All-Ukrainian Population Census has revealed the positive sides, as well as some shortcomings that should be taken into account in the following procedures of similar population registration in Ukraine. At that time, about 108 million UAH was spent on population registration, and a large number of instructors of different levels were involved and were trained. But even with such huge efforts, there were still some inconsistencies and inaccuracies during the procedure (not all the questions from the questionnaire were fully understood by the respondents, and some of them simply refused to answer, etc.) (Zastavetska, Zastavetsky, 2019).

The population census, which was scheduled for 2020, is supposed to take place for the first time in our country's history with the use of SMART technologies - smartphones, tablets, Internet surveys on websites,

etc. The experience of foreign countries, which have already conducted similar censuses, shows that it is still not necessary to give up traditional census paper forms. Therefore, a large number of trainers will be involved in the population registration procedure, who will record statistics in paper forms or on electronic media (tablets, smartphones).

In order to study all errors during the census procedure according to the new standards, a trial census will be conducted on the territories of two districts - Obolonskyy (Kyiv) and Borodnyanskyy (Kyiv region).

In 2001, more than 250.000 temporary instructor workers were hired to carry out the census, and in 2020 their number should be reduced to 100.000, mainly due to the introduction of the latest interviewing technologies. Any person who is of legal age and is a citizen of Ukraine can become such a temporary employee.

One of the interesting innovations in new census is that the survey procedure will now be completely anonymous. If the interviewee had to provide complete information including surname, first name and patronymic ealier, then this information will be replaced by the appropriate registration number now.

The current population registration, which is carried out continuously in our country - registration of births, deaths, changes of place of residence, number of emigrants and immigrants, gives an opportunity to see generalized data showing the population in Ukraine in general and in each of region or settlement in particular, as well as general features of gender-age structure and features of its dynamics. The abolition of compulsory residence permits, which took place in 2001, further complicates the ability to control population displacement, migration processes and to monitor demographic dynamics. However, the census will allow us to investigate all demographic phenomena at a much higher level, to identify those problems and contradictions that the current population registration is not able to identify - ethnic self-identification, language skills, property status of the population, the real number of people of retirement age, etc.

The population census questionnaire contains five main sections (modules), which are broken down into paragraphs (Fig. 1).

The planned for 2020 census would include two steps: an online census and a traditional census. The first stage (on-line) will last ten days, during which the respondents have the opportunity to answer the questions of the census form in the personal office of the census site, which is accessed in the presence of the relevant key (Perepys, 2019).

Demographic	 gender, age, place of birth, citizenship, ethnic origin or nationality, language, marital status, education, livelihoods
Employment	• place of work, a number of questions for the unemployed in terms of job search and employment
Migration	• interviewing the population about their current place of residence, past, plans for the future in terms of departure abroad; in addition, they will be asked whether the person has lived in other countries since 1991; a large block of questions is provided for internally displaced persons, where they will find out the reasons for moving and arranging their current residence
Living conditions	• questions about the area of housing, type of ownership, landscaping, year of construction
Agricultural activity of households	• an additional questionnaire for agricultural activities is being considered

Fig. 1. The main modules of the All-Ukrainian Population Census questionnaire in 2020.

During the second phase, it is planned to visit households by instructors who will provide statistical information on electronic media - tablets and smartphones that will be filled with vector digital maps and GPS navigation, which will allow to read the coordinates of the houses and provide GPS linkage to the map within a certain radius.

The preliminary census in 2001 indicated a number of issues that must be taken into account when conducting the next census:

- the respondents did not understand the individual questions (for example, when it comes to ethnicity, many respondents said that they are nationals of Hutsuls, Lemkies, Ruthenians, etc., not understanding that these categories are parts of one Ukrainian ethnic group – in fact, they are Ukrainians of different ethnographic groups);

- reluctance to answer specific questions, especially those concerning the wealth or income of a person or household;

- providing unreliable data, especially questions about education, property status, language proficiency;

- the inability to identify for themselves and indicate which language is the mother tongue of the respondent in mixed ethnic families. Often, the child has a good command of the language of both the father and mother, so it is difficult to indicate which of them is the mother tongue;

- difficulties in interviewing people belonging to particular religious groups, ethnic groups with a specific culture, who forbid the census, or allow only the male population to census.

Conclusion.

Summarizing the positive and negative trends in conducting online surveys and using SMART technologies during the census in different countries of the world, we can formulate specific recommendations for Ukraine:

1. There is the need to secure at the legislative level the mandatory participation in the census questionnaire (in electronic or traditional form).

2. Having analyzed the Canadian experience, we consider that it would be most appropriate to simplify the procedure for identifying a person when registering for a census. It may be enough to just enter the passport series and number.

3. The positive experience of Brazil demonstrates the benefits of purchasing special equipment – smart phones (or terminals) for the population census procedure. At relatively low cost, it will be possible to obtain quickly the information, pass it to statistical centers and reduce significantly the time for processing statistical information.

4. The most expedient and effective survey of the inhabitants of the country will be through registration on the web-site of the relevant statistical services. This can be done using a taxpayer ID or a query from the statistics service sent to the respondent's email, which he or she must confirm by clicking the link.

5. The convenience of the Internet census in this case is also that a separate office on the site can be opened for one household. And the data on each member can only be entered by one person at a convenient time.

6. The use of SMART-technologies makes it possible to reach practically the whole population, despite the transport accessibility of the respondent's place of residence, employment and other factors.

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