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Computer Modeling of Demographic Processes in the Region

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Abstract. Analysis of spatial differentiation of region-specific demographic processes helps identify the basic trends in population. Structural dynamic analysis can make use of computer simulations to sequence panel data in a logical and visually clear fashion.

1. Introduction

This paper analyzes demographic processes (reproduction, redistribution by gender and age) on national and regional levels. Spatial differentiation od demographic trends, gender and age distributions require a flexible demographic, social, and economic policy.

Most of Russia's regions are in demographic decline, which is why it seems important to study the factors behind this decline. Interregional disparity in terms of socioeconomic conditions, fertility and mortality rates might also be due to other factors such as ethnic traits, i.e. family traditions, multiple-child households; climates, etc.; this disparity distorts the existing connection between socioeconomic and demographic processes.

Comprehensive assessment of socioeconomic phenomena in a locative context as well as regional-level social policy performance analysis help compare the living standards in regions [1]. Demographic processes and their regional peculiarities need to be taken into account when outlining the action to maintain a stable regional socioeconomic system.

Systematic collection of qualitative and quantitative data for such performance assessment is currently a problem. Multidimensional statistical analysis can be applied to this data to group regions by typology. Scientifically sound monitoring of how the social policy performs [2] requires complex computer models of demographic processes. Qualitative and quantitative local demographic data form a knowledge base for indicative diagnosis of demographic security. Demographic zoning based on reproduction metrics is an important governmental tool [3].

Regional socioeconomic development is founded on the reproduction of human and natural resources, fixed and financial assets. This reproduction is in many ways founded on regional specifics: cultural and spiritual traditions, ethnicity, natural and climatic conditions. Regional differentiation and typology makes great use of computer models in the form of territorial mapping. Such models can represent projections. Demographic projections can be made separately for men and women, urban and rural dwellers. This is a multistaged method: its steps are to collect source data, to construct mortality matrices, to find fertility rates and migration nets; the last step is to make projections on population numbers. The projections have to be updated every five years [4]. Demographic projections are scenarios defined by factors that affect future demographic trends the most. Demographic projections depend on how reliable the initial estimates are and how accurately the future movement of persons is projected. Scenarios require collection and analysis of data that describe the current state of the art, identifying the factors that affect it, choosing the most important ones, and making the final projections on how the population trends will unfold [5].

The natural reproduction of regional population is a process affected by the factors that encourage or discourage childbearing or life expectancy. These factors may conventionally be grouped as follows:

– demographic factors: gender and age distribution, marriage and divorce rates;

– socioeconomic factors: income, education, employment rates, urbanization rates, availability and quality of healthcare, etc.;

– natural and biological factors: climate, natural disease foci, the onset of duration of reproductive age in women, etc.

Natural reproduction factors are closely interrelated. The natural and biological factors are permanent and non-controllable; the demographic factors emerge over long time and are the product of a long-term preceding demographic and socioeconomic policies. Socioeconomic factors are the most the dynamic tool for controlling the natural reproduction. Changes in socioeconomic conditions either boost the general fertility and mortality, or cause a rapid decline.

Computer modeling is intended to determine the type of stable demographic. A stable demographic is defined herein as a theoretical model of population with permanent age distribution, mortality and fertility rates, and thus retaining the same natural population growth rate. The actual population may be characterized as a stable demographic over a certain period of time provided that the society is not experiencing social or economic turmoil, is not undergoing any transformations. Progressive, static, and regressive demographics are particular cases of a stable demographic; they differ in age distribution. A progressive demographic grows rapidly thanks to fertility rates being above mortality rates; the latter is, however, also high as a rule. This phenomenon often occurs in traditional societies. A static demographic has zero natural population growth. A regressive demographic is a population in decline due to very low fertility that does not compensate for mortality [6]. In the late 19th century, Swedish demographer A. G. Sundberg proposed a ‘child-to-elderly’ ratio for each type of demographic. Let us look at these ratios in terms of age distributions. In a progressive demographic, 40% of the population is below working age, 10% is above; in a static demographic, 27% and 23%, respectively; in a regressive demographic, 20% and 30%, respectively [7, p. 63].

Data for the survey was sourced from official Federal State Statistics Service’s databases, the Regional Department of Rosstat in the Republic of Buryatia, and the Unified Interdepartmental Information and Statistics System [8,9,10,11].

2. Materials and methods

The Far Eastern Federal District of the Russian Federation (FEFD) comprises 11 entities. 10 of them were involved in observation, Chukchi Autonomous Okrug was excluded first as it deviated too significantly for the general sample in terms of socioeconomic metrics (e.g. its population density was only 0.07 persons per sq. km).

The first step was to determine the baseline demographic metric, which in this study was the local mortality rate. Analysis of this metric from 2000 through 2017 showed the Amur Oblast, Sakhalin Oblast, Zabaikalsky Krai, Primorsky Krai, and Khabarovsk Krai could be grouped together. Kamchatka Krai and Magadan Oblast were Group 2. Zabaikalsky Krai and the Republic of Buryatia were Group 3. The extremes were Jewish Autonomous Oblast, where the rate was the highest; and the Republic of Sakha (Yakutia), where it was the lowest. Thus, the ten regions were split into five groups, see Figure 1.

To see whether demographic processes were related, a representative was picked from each group: Khabarovsk Krai, Magadan Oblast, Republic of Buryatia, Jewish Autonomous Oblast, and Republic of Sakha (Yakutia), each representing the mean of its group.

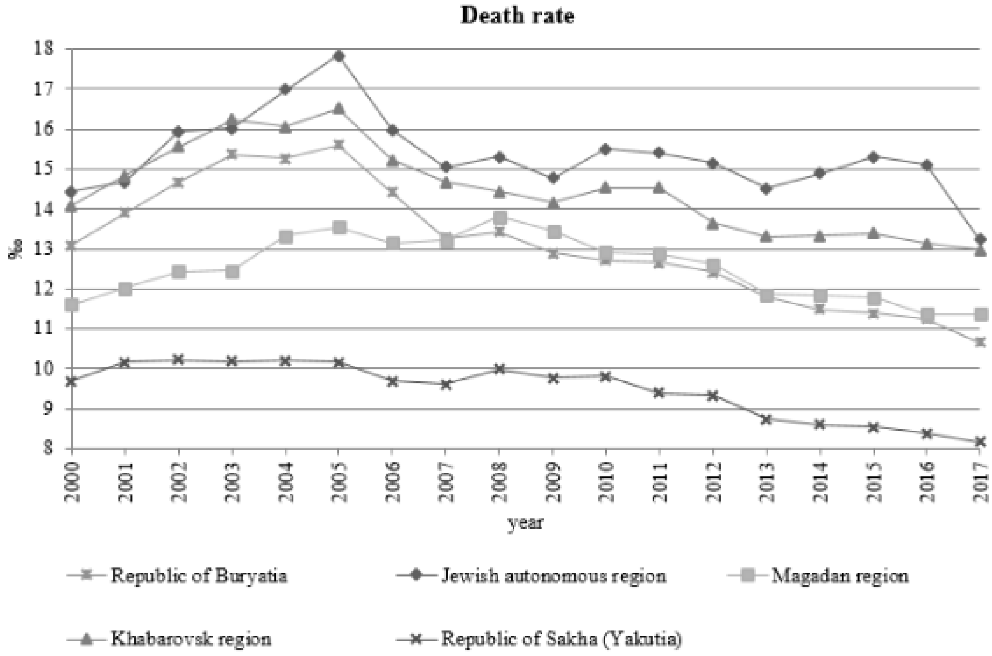


Figure 1. FEFD mortality rates.

The next step was to analyze the fertility rates in the five groups. In terms of fertility, the five regions split into four groups in 2000, three in late 2017. Most of the FEFD regions were classified as static demographics. A static demographic is one where the natural population growth is zero, 23.0% of the population are above working age, and the absolute population numbers are determined by migration.

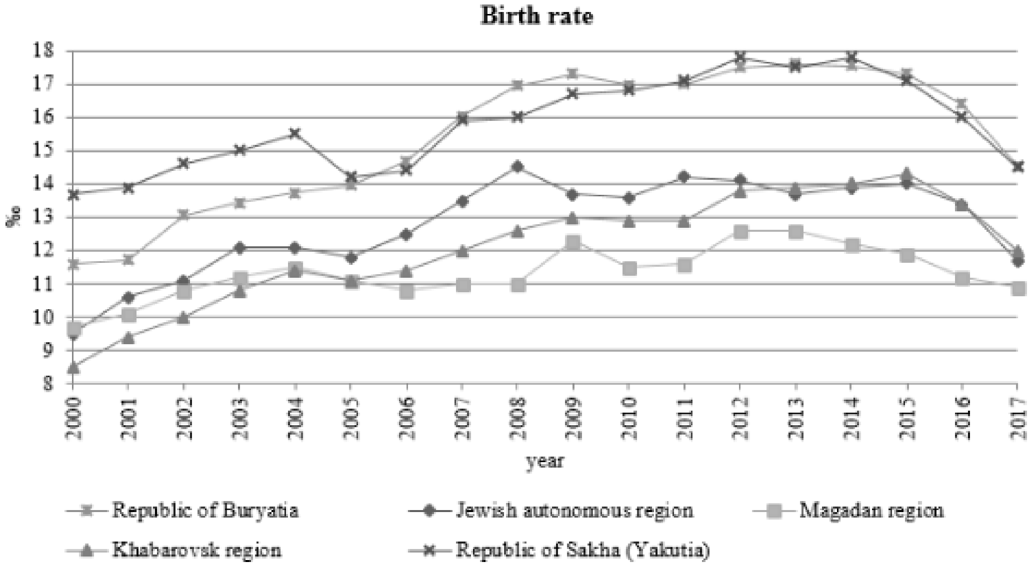


Figure 2. FEFD birth rates.

The next step was to find the marriage and divorce rates, see Figures 3 and 4. Khabarovsk Krai and Yakutia had the same value at the start of observations (6.1‰); at the end of the period, the closest values were observed in Khabarovsk Krai and Jewish Autonomous Oblast (7.8‰ and 7.7‰, respectively).

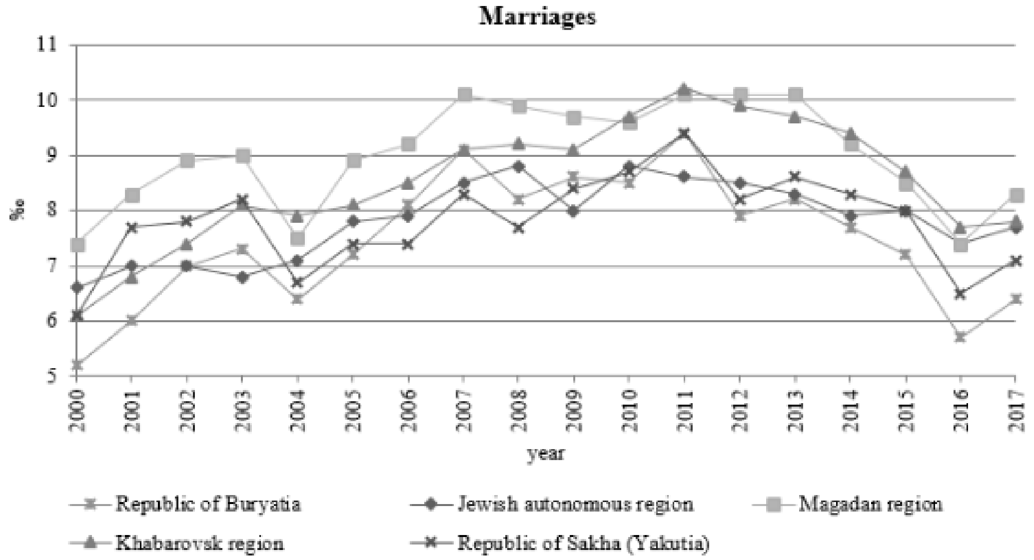


Figure 3. FEFD marriage rates.

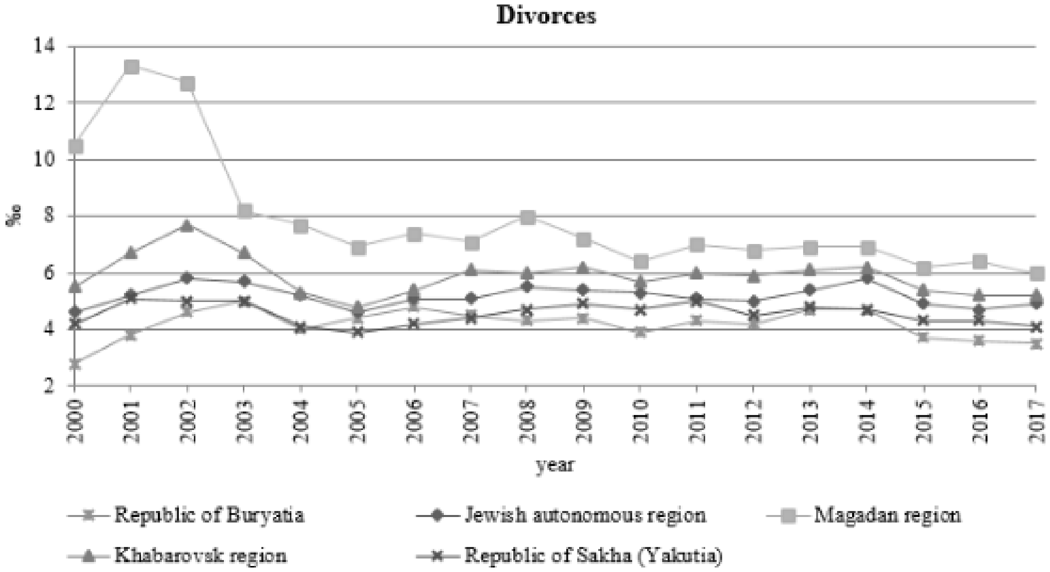


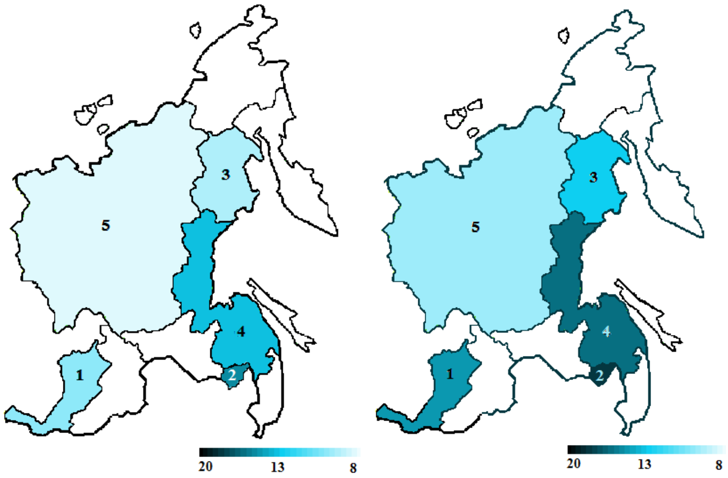
Figure 4. FEFD divorce rates.

Divorce rates went up in Magadan Oblast from 10.5‰ in 2000 to 6.0‰ in 2017. The same score rose from 2.8‰ to 3.5‰ in the Republic of Buryatia.

Fertility, mortality, marriage, and divorce rates are closely linked to each other and to the distribution by age. Notably, migration affects the demographic processes (fertility, marriage and divorce rates) and distributions by gender, age, etc. A study of migration fluxes and marital behavior over 1960–2014 in the Republic of Sakha grouped municipalities by the divorce rates [12].

3. Results

Computer modeling of the mortality rate is presented as an app that generates a database; the visual editor functionality is to be expanded further. Mortality rates peaked in 2005 in all five regions, see Figure 5.



a) (b)

Figure 5. Mortality rates: (a) 2005 (b) 2017; 1 Republic of Buryatia; 2 Jewish Autonomous Oblast; 3 Magadan Oblast; 4 Khabarovsk Oblast; 5 Republic of Sakha (Yakutia).

4. Conclusion

Demographic changes are mostly irreversible and create a new reality. Demographic crises and reduction in the natural reproduction of the workforce can be handled by intensifying economic growth and improving living standards to as to increase life expectancy and raise the upper working age. The demographic simulation app can trace the trends in regional metrics and help hypothesize for further analysis into spatial differentiation. The next step is to study how migration affects natural reproduction.

5. Acknowledgments

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6. References

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