

# The Econometric Model of the Social and Economic Regional Development Impact on Demographic Processes

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**Abstract**—The article proposes the econometric model of a social and economic regional development impact on demographic processes that largely determine the level of the regional human capital, which in turn is one of the most important factors for sustainable regional development. Using the created database (26 indicators for the period 2011-2016 covering all regions of the Russian Federation) and the methods of analyzing panel data with deterministic spatial effects, the functional dependence of the regional human capital demographic parameters on the indicators of economic development has been worked out. Data processing was implemented in R software environment. The component analysis was used in order to save the maximum quantity of information depending on multicollinear indicators. The results represent one of the comprehensive research stages related to regional human capital development modelling and take into account the correlation between the quality of life and the level of social and economic regional development. The proposed model can be used to elaborate and implement a strategy for the regional development and to make management decisions in the field of demography based on the optimal use of available resources.

**Keywords**—regional demographic processes, social and economic regional development, econometric modelling, regional human capital, level of regional development.

## I. INTRODUCTION

### A. Formulation of the Scientific Problem and Its Pertinence

Planning and management in a society should always be based on accurate information on the condition of human resources and factors that impact their qualitative and quantitative fluctuations the most. Demographic processes determine considerably the level of human capital that in its turn is one of the most important factors of sustainable development. In 1990-2015, Russia saw significant demographic transformations that resulted from changes in socio-economic environment on its way to market economy. Today, the influence of these spheres on the parameters of population formation has not waned, and that is why a

comprehensive and deep analysis should be conducted to identify the most important factors that determine the dynamics of demographic processes. This problem is exacerbated by significant differentiation existing among Russian regions by geography and economy, as it is in the regions that the country's main problems are integrated and become evident. The identification of the correlation between demographic processes and socio-economic development in the regions is a fundamental scientific goal that this article tries to achieve.

One of the methods used to analyse comprehensively the impact of socio-economic development on demographic processes in a region is econometric modelling that makes it possible to identify and quantitatively assess the correlation between socio-economic and demographic parameters when there are various statistic indicators, factors influence one another, and many factors impact simultaneously a certain resulting feature. The analysis of scientific development of this topic shows the lack of unified assessment criteria of socio-economic development's impact on demographic processes in a region, which results in significant discrepancy in the modelling's results.

Thus, there is a need for further improvement of methods and models that would help to, first of all, objectively and adequately assess the influence of economic criteria on demographic ones and, second of all, to provide regional management with a forecast to make rational management decisions in economics and demography. The goal of this article is to assess socio-economic development of Russian regions in the area of demographic processes dynamics. The main hypothesis of the research is that socio-economic situation in regions exerts key influence on current demographic processes there, and the level and nature of this impact can be identified with the help of the relevant econometric model.

### B. The Degree of Scientific Development of the Problem

Methodological aspects of the study of the correlation

between socio-economic development and demographic processes were first researched in the late 20-th century by renowned Soviet (Russian) and foreign experts, for instance, S. Strumilina, A. Vishnevsky, S. Kapitsa, A. Malkova, J. Forrester, M. Kremer and others [1-4]. Today, research in the field continues, and many publications using mathematic modelling on the basis of country and regional statistics cover the following aspects:

- assessment of the impact of individual socio-economic indicators on key demographic parameters of countries and regions [5-12]. The conducted research identified a close connection between life expectancy, GRP per capita, and average population income [5, 8]; the number of newborns and the volume of per capita consumption [6]; the birth rate and morbidity rate, etc. [7]; age structure and social state policy [10]; birth rate and housing availability [11]; life expectancy and property structure [12]. A number of scientists identify a new group of factor characteristics within social and economic indicators, namely "social stress", and study its impact on people's health [13];

- integral (generalized) assessment of socio-economic indicators' impact on demographic processes in countries and regions. A number of publications have established a strong correlation between demographic indicators and factors of economic development of territories, the development of social infrastructure, science and innovations, etc. [14-19], which as a whole confirms the hypotheses about the key impact of socio-economic development on demographic processes. Some scientists prove indirect and ambiguous influence of economic development on the dynamics and structure of Russian regions' population [20];

- assessment of impact of demographic factors on socio-economic development and life standards of the population as well as the assessment of the relations between economic and demographic aspects of regional development [21, 22].

Despite a great number of conducted studies, it must be said that socio-economic factors that define regional demographic dynamics and human capital development change in time and space, and demographic processes are very complex and multifaceted themselves. No proposed model provides exhaustive answers to demographic questions in Russian territories, and that is why evidence-based management of these processes calls for further research of the formalisation of the correlation between economic and demographic development. In our previous publications, we tried to assess the potential and modelling processes of human capital development on the micro-level and regional level [23, 24].

## II. THE ASSESSMENT OF THE IMPACT OF SOCIO-ECONOMIC DEVELOPMENT ON DEMOGRAPHIC PROCESSES IN RUSSIAN REGIONS

### A. Data and Methods

Data provided by the Federal Statistics Bureau of the Russian Federation "Russia's regions" [25] formed the information database of the research. Seven demographic and 18 socio-economic indicators were chosen by the authors for the purposes of econometric modelling, and a database was formed for 81 Russian Federation entities for the period

between 2011 and 2016. Demographic indicators comprise the population size, multipliers of natural and migration population growth, life expectancy, dependency ratio, child mortality, and the divorce and marriage ratio. This list is the foundation for the analysis of demographic processes both from the point of view of Russian statistics methodology [25] and that of the United Nations that publish regular review on global demographic trends [26].

The group of socio-economic indicators includes parameters of the GRP per capita, regional production structure, real investments into economy, the volume and structure of population's cash income, and inflation and budget revenues. The choice of these indicators was based on the list of basic indicators of socio-economic development of Russian federal entities designed by the Board for production force study under the Ministry of Economic Development and Trade of the Russian Federation and approved by the Government's Act No.717 of October 11, 2001 [27]. This method was improved by the authors, taking into account suggestions of experts who successfully tested various types of this method in their research [28, 29].

Panel data was formed by combining time and spatial ranges, and their analysis helped to construct the most flexible and meaningful models. Data processing was conducted in R software environment. In order to differentiate Russian regions by demographic parameters and to improve econometric models design process, regions were preliminarily divided into groups by means of cluster analysis. Regressive analysis helped to elaborate functional relations between demographic parameters of regional human capital and economic development indicators for every cluster in the context of panel structure.

### B. Results of the Modelling

Taking into account the regional differentiation of demographic and socio-economic situation, attempts have been made to create more thorough models using cluster analysis [30]. Using a tree diagram of hierarchical clusterisation based on seven 2016 demographic indicators with Euclidean distance as a proximity measure, the samples were divided into three clusters. Three clusters consisting of the 61<sup>st</sup>, 16<sup>th</sup> and 4<sup>th</sup> regions were formed using the k-average method. This clusterisation was tested with the help of Davis-Boldwin criteria, which was 0.82. The content of clusters is shown in Table 1.

The general characteristic of panel data models used in the research:

$$y_{it} = \alpha + X_{it}\beta + v_{it} \quad i = 1, N, t = 1, T \quad (1)$$

whence  $i$  is an object's number,  $t$  is time,  $\alpha$  is a constant term,  $\beta$  is a vector-column of size multipliers  $k \times 1$ ,  $X_{it} = (x_{1,it}, x_{2,it}, \dots, x_{k,it})$  is a vector matrix line  $k$  of explicative variables,  $v_{it} = u_i + \varepsilon_{it}$  is a accidental error with unobservable individual effects  $u_i$  and residual disturbance  $\varepsilon_{it}$ .

The method Best Subsets helped to construct panel data models of three types of the correlation between demographic indicators and socio-economic factors: end-to-end models, models with deterministic, and accidental spatial effects.

Relevant tests (Wald, Hausmann and Breusch-Pagan test) helped to choose the best elaborated models, namely models with deterministic effects. Models were elaborated for all the clusters as a whole (81 region) and for every individual one.

Cluster models are of higher quality in comparison with the collective model as determination multipliers are bigger in that case. For instance, life expectancy at birth indicator's  $y_5$  model designed for all the examined regions with meaningful multipliers with their variables has 0.75 determination multiplier, which is smaller than in case of similar regressions calculated for individual clusters (0.8, 0.76, 0.83).

TABLE I. THE COMPOSITION OF CLUSTERS AS RESULTED FROM THE RESEARCH

Cluster No.	Regions
1	Belgorod Oblast, Bryansk Oblast, Vladimir Oblast, Voronezh Oblast, Ivanovo Oblast, Kaluga Oblast, Kostroma Oblast, Kursk Oblast, Lipetsk Oblast, Orel Oblast, Ryazan Oblast, Smolensk Oblast, Tambov Oblast, Tver Oblast, Tula Oblast, Yaroslavl Oblast, Republic of Karelia, Republic of Komi, Vologda Oblast, Kaliningrad Oblast, Leningrad Oblast, Murmansk Oblast, Novgorod Oblast, Pskov Oblast, Republic of Adygea, Astrakhan Oblast, Volgograd Oblast, Rostov Oblast, Stavropol Krai, Republic of Bashkortostan, Republic of Mary El, Republic of Mordovia, Republic of Tatarstan, Udmurt Republic, Chuvash Republic, Perm Krai, Kirov Oblast, Nizhny Novgorod (Nizhegorodskaya) Oblast, Orenburg Oblast, Penza Oblast, Samara Oblast, Saratov Oblast, Ulyanovsk Oblast, Kurgan Oblast, Sverdlovsk Oblast, Chelyabinsk Oblast, Republic of Buryatia, Republic of Khakassia, Altai Krai, Zabaykalsky Krai, Krasnoyarsk Krai, Irkutsk Oblast, Kemerovo Oblast, Novosibirsk Oblast, Omsk Oblast, Tomsk Oblast, Primorsky Krai, Khabarovsk Krai, Amur Oblast, Magadan Oblast, Sakhalin Oblast
2	Nenets Autonomous Okrug, Republic of Kalmykia, Republic of Dagestan, Republic of Ingushetia, Kabardino-Balkar Republic, Karachay-Cherkess Republic, Republic of North Ossetia-Alania, Chechen Republic, Khanty-Mansiysk Autonomous Okrug, Yamalo-Nenets Autonomous Okrug, Republic of Altay, Republic of Tyva, Republic of Sakha (Yakutia), Kamchatka Krai, Jewish Autonomous Oblast, Chukotka Autonomous Okrug
3	Moscow, Moscow Oblast, St. Petersburg, Krasnodar Krai.

It was also established, after the comparison of statistically meaningful models for all the regions and for clusters, that preliminary clusterisation changes the content of many meaningful predictors of demographic indicators. For instance, clusterisation changed the content of meaningful predictors in case of life expectancy indicator (Table 2).

TABLE II. EXPLANATORY FACTORS FOR LIFE EXPECTANCY INDICATOR'S MODEL ELABORATED DURING THE RESEARCH

Cluster No.	Predictors
Cluster No.1	$x_1$ is the percentage of the employed population in the labour force (%)
	$x_6$ is a gross regional product per capita (rubles)
	$x_9$ is an industrial production index (% in relation to the previous year)
	$x_{12}$ is the volume of shipped goods, finished jobs and provided services by economic activity type "Production and distribution of electricity, gas and water" per capita (rubles)
	$x_{13}$ is the volume of agricultural produce per capita (rubles)
Cluster No.2	$x_3$ is the volume of consumer expenses per capita per month (rubles)
	$x_4$ is the percentage of consumer expenses in the total population income (%)
	$x_6$ is a gross regional product per capita (rubles)
	$x_{13}$ is the volume of agricultural produce per capita (rubles)
	$x_{17}$ is the consolidated regional budgets revenues per capita (rubles)
Cluster No.3	$x_{15}$ is the aggregate turnover in retail business, public catering and commercial services per capita (rubles)
General model	$x_1$ is the percentage of the employed population in the labour force (%)
	$x_3$ is the volume of consumer expenses per capita per month (rubles)
	$x_6$ is a gross regional product per capita (rubles)
	$x_{12}$ is the volume of shipped goods, finished jobs and provided services by economic activity type "Production and distribution of electricity, gas and water" per capita (rubles)
	$x_{13}$ is the volume of agricultural produce per capita (rubles)
	$x_{17}$ is the consolidated regional budgets revenues per capita (rubles)

The analysis of the quality of designed models, in particular relative errors of approximation, enables us to conclude that an individual approach is needed for every cluster, in other words, that preliminary clusterisation is necessary.

For example, the general model of life expectancy for the  $i^{\text{th}}$  region elaborated for 81 region's data is the following:

$$y_5 = \alpha_i + 0.10576x_1 + 0.42746x_3 + 0.17572x_6 + 0.15009x_{12} + 0.09156x_{13} + 0.09145x_{17}; \quad (2)$$

The models of this indicator for the regions of the first, second and third clusters are:

$$y_5 = \alpha_i + 0.430278x_1 + 0.327256x_6 - 0.024151x_9 + 0.179732x_{12} + 0.048978x_{13}, \quad (3)$$

$$y_5 = \alpha_i + 0.358969x_3 + 0.340253x_4 + 0.236900x_6 + 0.496513x_{13} + 0.273016x_{17}, \quad (4)$$

$$y_5 = \alpha_i + 0.355479x_{15}. \quad (5)$$

Clusterisation helped to lower average relative error of approximation for life expectancy indicator model in the first

cluster regions by 15%, in the third cluster by 29%, but the indicator modelling error  $y_3$  in the second cluster became 27% bigger in comparison with the errors in case of a model for these regions without clusterisation.

Thus, the conducted research enables us to make a conclusion that it is preferable to use regressive models for individual clusters. The correlations of demographic indicators identified by the research, in particular the multiplier of demographic pressure and life expectancy and socio-economic factors, can be used separately with a view to assess the influence of socio-economic development on demographic processes and to further study the factors of the formation and development of human capital in Russian regions.

### III. FINAL CONCLUSIONS

The conducted research made it possible to come to following conclusions.

1. The assessment of the impact of socio-economic development on demographic processes in the region is an important scientific and practical challenge for national and regional management that is especially crucial in the context of growing differentiation within the country by socio-economic and demographic characteristics. The analysis of scientific publications showed that there are many approaches to modelling the correlation between the socio-economic and demographic development.

2. The database using 25 indicators in 81 Russian regions from 2011 to 2016 helped to establish functional relations between demographic parameters of regional human capital and economic development indicators. In order to improve the quality of the models, a preliminary clusterisation was conducted using seven demographic indicators. Econometric models were calculated both for all 81 regions as a whole and for every cluster in particular.

3. The analysis of the research's results enables us to make a conclusion that it is preferable to use cluster analysis to model demographic indicators. Indeed, preliminary clusterisation of the Russian Federation regions ensured higher quality of demographic situation indicator models and a differentiated approach to the identification of explanatory variables.

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