Analysis Models for Territorial Variation of Demographic Phenomena. The Case of Romania,

Mariana BĂLAN,
Raluca IORGULESCU

Mariana BĂLAN, Ph.D., professor, Institute for Economic Forecasting-NIER, Romanian Academy

Raluca IORGULESCU, researcher, Institute for Economic Forecasting-NIER, Romanian Academy

Abstract

Demographic phenomena that characterized the last decades have influenced its spatial distribution. Demographic aging of population has become lately an extremely sensitive and sometimes thorny issue, whose resolution requires a joint and coordinated effort of all decision makers in each country. Demographic aging has a profound impact on all generations and for most areas of economic activity and for the poverty level. As a member state of the European Union, Romania, "enrols", from the point of view of an aging population, in the European trend, sometimes was exceeding, in the negative, the levels of other Member States. Regional disparities, highlighted through different methods, recommend using multi-criteria analysis to determine the influence of various socio-economic factors on demographic factors. In the first part, the paper presents a brief analysis of the evolution of demographic phenomena in Romanian development regions. Econometric and stochastic methods for territorial forecasting of demographic phenomena are presented, which will be the basis for future research.

Keywords: demographic phenomena, regional distribution, stochastic models, econometric estimates, forecast
JEL Classification: C32, C52, C87, J10, J11

Introduction

Population is the essential part of human development. Population size and quality are two values in a complex connection that determines all socio-human processes (including poverty) in a given space. Also, the evolution of the intensity and specificity of this phenomena depend on them.

Demographic phenomena that characterized the last decade have influenced population's spatial distribution. At the country level, population density shows significant variations.

The analysis of population dynamic reveals a number of trends i.e. extremely high decrease of birth rate, respectively, of female fertility; high mortality intensity; infant mortality still remains very high, despite the progress made since 1990; maintaining the average life at values low in the European context; increasing internal rural-urban migration flows. Also, accelerated aging and the increased "pressure" of the elderly on adult-potentially active population, and implicitly on important systems in society (health, welfare, social security), has strong implications for economic and social policies.

Fertility declined in all counties, but with different intensity; Moldova has the highest fertility values, while Brasov and Bucharest counties have the lowest. Life expectancy at birth has dropped in more than half of the Romanian counties. After high internal and external migration flows in 1990, spatial mobility of the population decreased in intensity.

In the last decades, the evolution of demographic phenomena in Romania has led to changes in the age structure of the population, with both demographic and socio-economic implications. In particular, during the past ten years, demographic aging has increased, caused by an increasing number and share of adult and elderly population, in the same time with a decreasing number and share of people younger than 15.

Due to a different evolution in time of the level of demographic phenomena and internal and external movement of the population, there are noticeable differences in age structure at regional level.

A variety of econometric and stochastic – especially Markovian – models have an important role in forecasting the evolution of macroeconomic indicators needed to revitalize economic growth. With their help, various economic phenomena and the correlations among them can be analysed and forecast.

In economics, the use of these methods, especially for Romanian economy, was less extensive. Tackling the demographic process, the dynamics of the labour market parameters using Markov or semi-Markov chains or processes, represents a substantial contribution to the development of techniques for modelling economic phenomena and a useful tool for economic forecasting.

The application of Markov modelling to economic phenomena and to issues related to some economic sectors, for analysis of the correlation degree of the main macroeconomic indicators in order to develop macroeconomic forecasts, can help revitalize economic growth which has become a priority of macroeconomic policy.

1. General demographic profile by regions in Romania

Romania's population represents 3.9% of EU-28 population on an area 5.5% of the total territory of the 27 Member States. The average population density in Romania, (89.6 inhabitants per km^2), is lower than in Germany, the UK and the Netherlands, but higher (5-6 times) than in Finland and Sweden. Romanian population density is closer to that of Greece and Spain.

In many counties industrialized before 1990 (Prahova, Dâmboviţa, Iasi, Galati), population density is well above country's average density (130.5-171.6 inhabitants / sq. km). This is due to intensive rural-urban migration to fill the jobs created during industrialization.

There are also differences among regions in terms of population density. Excluding the Bucharest-Ilfov region with 1237.7 inhabitants / sq. km—due to the urban agglomeration of the capital—the highest population density is recorded in the North East Region (about 100.1 inhabitants / sq. km). This region has the largest demographic dynamism of the country. The lowest density is in the West Region (59.6 inhabitants / sq. km), the region with the largest decrease in population and with a mountainous landscape over much of the area.

The urbanization of the regions is also rather different. Except for Bucharest, the most urbanized regions are Western Region and Central Region (with 62.7% and 58.9%, respectively, urban population).

Differently, in the east, North-East Region and throughout the south of the country in Muntenia-South and South-West – Oltenia regions, the rural population is still predominant (57.1%, 58.6% and 52%, respectively); these are regions with large lowland areas where agricultural activities are still prevalent.

After decades of significantly increasing the number of inhabitants in cities, in the period 1990-2012, urban population has decreased continuously in almost all development regions. Exceptions are the North-East, South-West Oltenia and Muntenia South where urban population exceeds rural population for the entire period.

The decrease of the urban population had sometimes demographic causes, but it was mainly the effect of the economic downturn when some of the inhabitants have left the cities when their jobs were gone. As a result of these developments, the structure of the urban system was slightly changed: an increased number of small towns and a lower number of cities. Although, a distinctive feature for the Romanian urban system is a relatively balanced distribution in the territory of the remaining cities.

For the operation and support of the national urban system, significant population decline in some core cities with over 100 thousand inhabitants, is vital. This decrease results in lowering their role and functions in the region, weakening the potential for development in the whole area of influence.

2. Changes in geo-demographic structure by region

In general, for Romania, demographic indicators have values below the EU-27 average. Between 1992 and 2012, Romanian population decreased by 8.14%. The Romanian demographic decline is due to a strong fertility decrease and increased mortality and emigration, especially of young people.

Infant mortality rate (deaths per 1,000 live births) in Romania is among the highest in Europe, with 9.4 ‰ versus 3.9 ‰ in the EU-27 in 2011.

In 2012, in Romania, life expectancy at birth was lower than the EU-27 values with 6.1 years for men and 4.5 years for women (men: 70.7 years in Romania compared to 76.8 years in the EU-27; women: 77.9 years compared to 82.4 years in the EU-27).

As a result of slow but continuous demographic aging, increased in the past decade as a result of the low birth rate, Romania's population structure by age groups went through significant changes. As a result, the share of the population under 15 is decreasing, while the share of elderly population over 60 years is growing.

In 2013, in Romania, the proportion of people aged 65 and over was 3.7%, lower than the EU average, while for youth it was higher than the EU average, which means that the process of demographic aging is more pronounced at EU level compared to Romania. In these circumstances, the demographic "pressure" exerted by both young and old (potentially inactive persons) on adults (potentially active people) oscillates around 50%, with a slight decreasing tendency due to a reduced pressure of the youth as a result of lower birth rates.

South Muntenia and South-West Regions have the highest percentage of population aged 65 years and over in the total population (6.72% and respectively 16.43% at July 1, 2011). The number of administrative units for which the share of elderly exceeds 30% of the total population has increased, according to the 2011 census, from 67 (2.27% of total communes, towns and municipalities) in 1995 to 216 (6.79% of total) in 2010. Rural areas far from the polarization of big and medium cities (south of Muntenia - especially Teleorman county and southwestern counties of Oltenia, mountainous and hilly areas of western Transylvania - Apuseni Mountains and Somes Hills, Banat Mountains area, etc.) are areas where demographic aging is noticeable.

As a result of internal and international migration, the share of young people in total population per region is very similar, varying between 29.7% in the North-West Region and 27.4% in the Central Region. The 2011 Census shows that the number of administrative units with a very low proportion of young people (below 10% of total population) increased from

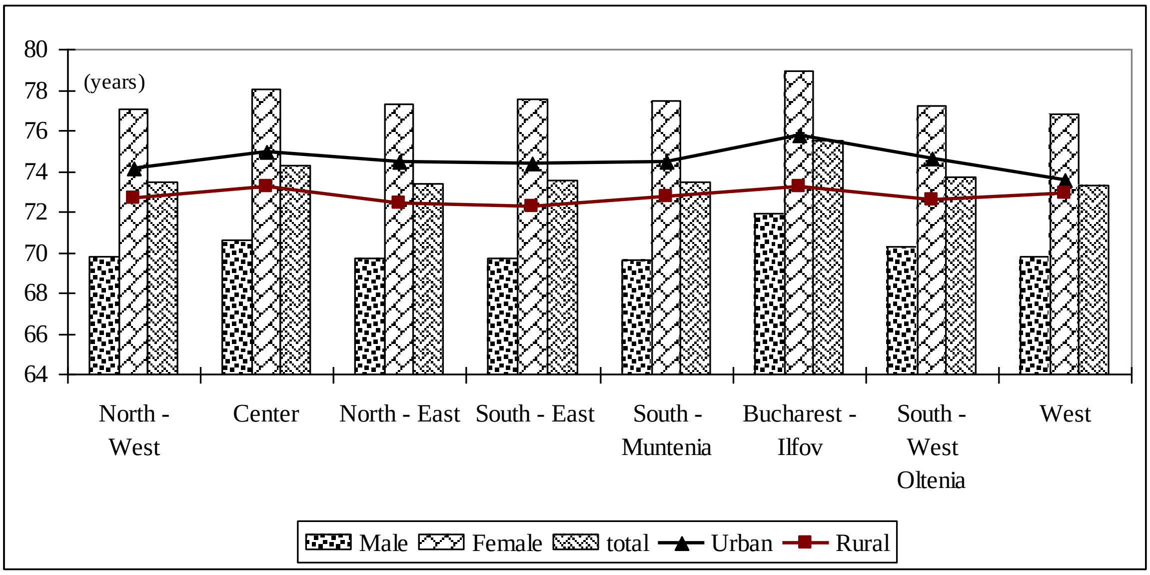
25 (representing 0.85% of total communes, towns and municipalities) in 1995 to 60 (1.89% of total) in 2010.

Migration and changing demographic practices of the youth induced the regional changes in demographic structures. In 1995, young population was well represented in many regions such as Moldova (Iaşi, Suceava, Bacau and Vaslui counties), Maramures and Bistrita Nasaud, southern and south-western Transylvania, Banat and Dobrogea. Fifteen years later, in those regions the demographic weight of this age group does not have the same significance. In 2010, young people had a significant presence (percentage) only in small areas of Moldova (Iaşi, Vaslui and Bacău counties) or in southern Transylvania (Braşov and Sibiu counties).

Age pyramid variations and an increased demographic dependency illustrate the demographic changes produced in Romania in the past two decades. Regarding the changes of the age pyramid, due to lower birth rates and to the migration of young people, between 1992 and 2012 its base was reduced, emphasizing the adult population segment.

Regionally, in 2011, life expectancy range was from 73.3 years in the West region to 75.5 years in the Bucharest-Ilfov region, differing strongly by area of residence and sex (Fig. 1). The largest spread by sex was nearly 8 years for women in South-Muntenia region, while by residence the strongest difference was recorded in the West region (2.6 years for urban population). The very small difference (0.7 years) between the average life expectancy by residence in the South-West region, shows almost similar living conditions for the two types of habitat.

Fig. 1. Life expectancy by region, sex and residence, year 2011



Source: Statistical Yearbook Romania 2012

3. Models of analysis and forecast of the population by region

To analyse and forecast demographic phenomena, in the literature, both global and analytical models are mentioned. Global forecasting models are being used less and less since they are based on the assumption that past essential social and economic features of population development will continue in the future or their change will occur gradually.

Analytical methods or the components method for demographic forecasting, take into account both the male and the female cohorts for each age group. This method performs a separate analysis of the changes that will affect every part of the population. The variables used in this method are: population by age on July 1 of the base year considered; fertility rates for base year; mortality rates by age and projected life expectancy at birth; internal and external migration balance by age and sex.

The basic relationship for this method is:

$$P_{x+1}(t) = \frac{P_x(t) - 0.5D_x(t) + 0.5N(t) + 0.5IM_x(t) - 0.5EM_x(t)}{1 + 0.5d_{x+1}(t+1) - 0.5f_x(t+1) - 0.5im_{x+1}(t+1) + 0.5em_{x+1}(t+1)} \quad (1)$$

where:

$P_x(t)$ – population aged x, at time t;
$D_x(t)$ – number of deceased age *x*, during the year (*t* is the centered point);
N(t) – number of live births during the year (*t* is the centered point);
$IM_x(t)$ – number of immigrants age x during the year (*t* is the centered point);
$EM_x(t)$ – number of emigrants aged x during the year (*t* is the centered point);
$d_x(t)$ – mortality rate for individuals of age x, during the year (*t* is the centered point);
$f_x(t)$ – fertility rate for women aged x (15-49) during the year (*t* is the centered point);
$im_x(t)$ – immigrant rate for persons age x, during the year (*t* is the centered point);
$em_x(t)$ – emigrant rate for persons age x, during the year (*t* is the centered point);

The number of deaths, live births and migrants at time t +1 is calculated using the equations:

$$\begin{aligned} D_x(t+1) &= P_x(t) \cdot d_{x+1}(t+1) \\ N_x(t+1) &= \sum f_x(t+1) \cdot P_x(t+1) \\ IM_x(t+1) &= P_x(t+1) \cdot im_{x+1}(t+1) \\ EM_x(t+1) &= P_x(t+1) \cdot em_{x+1}(t+1) \end{aligned} \quad (2)$$

Sometimes, for years when no data was available, the values for specific rates (mortality, fertility, migration) are linearly interpolated.

4. Markov demographic models

Most demographic models are deterministic. These models are produced in two forms: first category uses the discrete variable "time" and a discrete age scale, while the other category uses time and age scale as continuous variables.

The assumptions for the discrete stochastic model are:

- the census of the female population (population F) occurs at discrete time intervals, n = 1, 2, 3 ...;
- the population is divided into k age groups $k \in Z^*$;
- the number of women in age groups at time *n* is given by the random variable $\eta_n(j)$. Therefore, variable's momentum and random dispersion become: $E\eta_n(j) = M_{j,n}$ and $D\eta_n(j) = D_{j,n}$
- if a member of the age group j at time *n-1* gives birth to a girl at time *n*, the number of women in the age group 0 at time *n* whose mothers belonged to the age group *j*, is a random variable $\eta_n^{(j)}(0)$, with $\eta_n(0) = \sum_{j=0}^{k} \eta_n^{(j)}(0)$;

- probability p_j that a person aged *j* at time *n* will be in the age group *j+1* after a unit of the time interval, is fixed and j < k is positive and $p_k = 0$. These probabilities are assumed independent, so $q_j = 1 - p_j$;
- probability b_j that a person aged *j* at time *n* give birth to a single girl in the interval (*n, n + 1*) and this girl to be active in the group 0 at time *n+1* is fixed and they are assumed independent. So: $d_j = 1 – b_j$;
- birth and death processes are assumed to be independent;
- changes in the structure of the male population are assumed to be consistent with the assumptions of a constant measure of fertility $\{b_j\}$;
- multiple births are ignored.

For the proposed analysis, the assumptions are:

- λ and μ are discrete random variables with positive integral values;
- λ'_1 and λ'_1 are random variables with binomial distributions $B(\lambda, p_1)$, $B(\lambda, p_2)$, and conditional on λ.

Using the following equations:

$$\begin{cases} \mathbf{E}\lambda_1' = p_1\mathbf{E}\lambda \\ \mathbf{D}\lambda'_1 = p_1^2\mathbf{D}\lambda + p_1 q_1 \mathbf{E}\lambda \end{cases} \tag{3}$$

$$\begin{cases} \mathrm{Cov}\left[\lambda_1', \lambda_2'\right] = p_1 p_2 \mathbf{D}\lambda \\ \mathrm{Cov}\left[\lambda_1', \mu'\right] = p_1 p_3 \mathrm{Cov}[\lambda, \mu] \end{cases} \tag{4}$$

where $q_1 = 1 – p_1$, the demographic Markovian model becomes:

$$\begin{aligned} &\mathbf{E}\eta_{n+1}(0) = M_{0,n+1} = \sum_{j=o}^{k} b_j M_{j,n} \\ &\mathbf{E}\eta_{n+1}(1) = M_{1,n+1} = p_0 M_{0,n} \\ &\mathbf{E}\eta_{n+1}(2) = M_{2,n+1} = p_1 M_{1,n} \\ &\ldots \\ &\mathbf{E}\eta_{n+1}(k) = M_{k,n+1} = p_{k-1} M_{k-1,n} \end{aligned} \tag{5}$$

Further, using equations (3) and (4):

$$\mathbf{D}\eta_{n+1}(j+1) = D_{j+1,n+1} = p_j^2 D_{j,n} + p_j q_j M_{j,n}\ ,\ j \ge 0 \tag{6}$$

$$\begin{aligned} &\mathrm{Cov}[\eta_{n+1}(j+1), \eta_{n+1}(h+1)] = p_j p_h \mathrm{Cov}[\eta_n(j), \eta_n(h)]\quad ,\ j, h \ge 0,\ j \ne h \\ &\mathrm{Cov}[\eta_{n+1}^{(j)}(0), \eta_{n+1}(h+1)] = b_j p_h \mathrm{Cov}[\eta_n(j), \eta_n(h)]\quad ,\ j \ne h \\ &\mathrm{Cov}[\eta_{n+1}^{(j)}(0), \eta_{n+1}^{(h)}(0)] = b_j b_h \mathrm{Cov}[\eta_n(j), \eta_n(h)]\quad ,\ j \ne h \\ &\mathbf{D}\eta_{n+1}^{(j)}(j+1) = b_j^2 D_{j,n}^2 + b_j d_j M_{j,n}\ ,\ j \ge 0 \end{aligned} \tag{7}$$

If by definition, $\eta_{n+1}(0) = \sum_{j=0}^{k} \eta_{n+1}^{(j)}(0)$, then,

$$\begin{aligned} \mathbf{D}\eta_{n+1}(0) &= \sum_{j=0}^{k} \mathbf{D}\eta_{n+1}^{(j)}(0) + \sum_{j \ne h}\sum \mathrm{Cov}\left[\eta_{n+1}^{(j)}(0), \eta_{n+1}^{(h)}(0)\right] = \\ &= \sum_{j=0}^{k} \left(b_j^2 D_{j,n} + b_j d_j M_{j,n}\right) + \\ &+ \sum_{j \ne h}\sum \mathrm{b_j b_h} \mathrm{Cov}[\eta_n(j), \eta_n(h)] \end{aligned} \tag{8}$$

and results:

$$\mathrm{Cov}\left[\sum_{j=0}^{k}\eta_{n+1}^{(j)}(0),\eta_{n+1}(k+1)\right]=\mathrm{Cov}\left[\eta_{n+1}^{(j)}(0),\,\eta_{n+1}(h+1)\right]+ \\ +\sum_{j=0}^{k}\mathrm{Cov}\left[\eta_{n+1}^{(j)}(0),\,\eta_{n+1}(h+1)\right] \tag{9}$$

$$\mathrm{Cov}\left[\sum_{j=0}^{k}\eta_{n+1}^{(j)}(0),\eta_{n+1}(k+1)\right]=\mathrm{b_h}\,p_h D_{h,n}+\sum_{j\neq h} b_j\,p_h \mathrm{Cov}\left[\eta_n(j),\eta_n(h)\right]$$

For the sample considered, equations (5) - (9) completely define the recurrence relations for average, variance and covariance. In matrix form it can be written:

$$\begin{pmatrix}\mathbf{M}_{n+1}\\ \mathbf{V}_{n+1}\end{pmatrix}=\begin{pmatrix}\mathbf{A} & \mathbf{O}\\ \mathbf{B} & \mathbf{AxA}\end{pmatrix}\begin{pmatrix}\mathbf{M}_{n}\\ \mathbf{V}_{n}\end{pmatrix} \tag{10}$$

where the vector V contains elements of variance and covariance and A is Leslie matrix defined by:

$$\mathbf{A}=\begin{pmatrix} b_1 & b_2 & \dots & b_{k-1} & b_k\\ p_0 & 0 & \dots & 0 & 0\\ 0 & p_1 & \dots & 0 & 0\\ . & . & \dots & . & .\\ . & . & \dots & . & .\\ . & . & \dots & . & .\\ 0 & 0 & \dots & p_{k-1} & 0 \end{pmatrix} \tag{11}$$

This yields the following relation between variance and covariance:

$$\mathbf{V}_{[n]}=(\mathbf{A}x\mathbf{A})^n\mathbf{V}_{[0]}+\sum_{i=1}^{n}(\mathbf{A}x\mathbf{A})^{n-i}\mathbf{BM}_{i-1} \tag{12}$$

5. Conclusions

Romania’s demographic situation is not an isolated case in the European context. All European countries pass through a demographic crisis.

The significant decrease of Romania's population since 1990 has a very complex source. Therefore, the demographic situation of the country cannot be explained only through the demographic developments of the last 24 years: declining birth rates, increased mortality and negative external migration.

At the territorial level, gaps in the key demographic indicators, structure, and population density are found; demographic differences based on residence (rural vs. urban), among counties, among cities—depending on their size, are still present.

In the current situation, when trying to achieve a functional open market economy, it is expected that decision-makers use various methods and estimation techniques to study macroeconomic development and in the same time to provide a scientific support for economic forecasts. One of the key elements of macroeconomic analysis is the study of demographic trends.

The paper presents some key econometric and stochastic models, used in many domains for analysis and study of complex systems, as methods of analysis and forecast of regional demographic phenomena.

Acknowledgement

This paper presents some results obtained in the research projects "Non-linear models for analysis and forecast of socio-economic effects of demographic aging" - coordinator M. Bălan and "Models for poverty analysis and forecasting: From econometric modelling to integrated multi-scale analysis with a flow-fund model" – coordinator R. Iorgulescu, part of the research plan of the Institute for Economic Forecasting/2014.

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