ANALYSIS OF THE MACROECONOMIC EFFECTS OF POPULATION AGING IN ROMANIA USING NON-LINEAR MODELS

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Abstract

Demographic ageing has turned lately into an extremely sensitive and sometimes thorny issue with deep impact on all generations and on most fields of economic activity.

Romania, just like any other European countries is faced currently with demographic decrease. The demographic changes of the next decades are susceptible of having a significant impact on Romania's economic development. Demographic ageing as such, negatively affects GDP growth by diminishing factors' entry. Moreover, this phenomenon has a negative impact on GDP per capita, especially for the future, mainly because of the decline in the employed population segment. In this context, knowing the future evolution of population plays a determinant role in adopting measures and policies for economic growth.

The paper intends, in this stage of research, to analyse and forecast the demographic ageing of Romania's population by using non-linear models.

Keywords: demographic ageing; vital statistics indicators; non-linear models, forecasts

JEL Classification: E24, J21

1. Introduction

One of the most significant issues of humankind in the 21st century will be the demographic ageing of the population. It shall trigger important issues regarding the socio-economic development for various regions of the world. Both in economically developed countries, and in the developing ones the weight of elderly in the population's structure increases at a very high rate.

The demographic trends at world level and, implicitly, at European Union level indicate a longer and healthier life and put in question topics such as the new costs of an ageing society, the equity between generations, the higher importance granted to raising children and the work-life balance in fostering family life, the intergenerational relationships and the new poverty threat [1].

As member-state of the European Union, Romania is "circumscribed" from the viewpoint of demographic ageing in the European trend, sometimes exceeding with negative connotations the levels recorded by the other member-states. This situation is due, largely, to the low efficiency of the economic-social policy measures implemented during the last years correlated also with the inadequate use of budgetary resources which are rather limited, as it is, compared with the ones of the other member countries.

Romania is faced already with the complex economic and social consequences of a population in a slow but ongoing process of demographic ageing [2]. As result of population's ageing the contribution of the workforce to GDP growth diminished and, as result, next to other factors, the potential GDP of Romania decreased to 1.3% in 2013 from 5% in the year 2004. To this, the increase in expenditures for social assistance and health led as well to increased pressure on the state budget and the ageing of the population increases the weight of households with a low savings rate.

The severe demographic imbalance of the country triggers harsh economic and social imbalances: on the labour force market, in the pensions' system, for the health and education services, in the general social protection system, in the budgetary incomes and expenditures system, etc. A determinant factor for defining and structuring a viable strategy for the sustainable development of the country, the population should remain the core focal element of attention for the deciding factors and for the society as a whole.

The demographic projections represented, always, a fundamental instrument in elaborating economic and social development strategies and programmes.

The use of non-linear models allows for estimating the consequences of demographic ageing on some macroeconomic indicators. Understanding the evolution of labour resources and of the active population is necessary for substantiating the economic and social development programmes.

2. Brief presentation of Romania's demographic characteristics

The last 25 years were characterised by the continuing diminishment of Romania's population. The swift and significant decreases in the birth rate, the recrudescence of mortality and negative external migration have changed dramatically the demographic landscape of Romania. The year 2014 is the 25th year of demographic decline, a period in which Romania lost 1.95 million inhabitants which means 8.4% from the population the country had at the beginning of the nineties [3].

Romania is among the top five member-states of the EU (next to Slovakia, Poland, Latvia, and Slovenia) that will now the highest rate of population ageing in the following decades. The median of the total population age will be of 46 years of age in the year 2030 and 52 years in the year 2060 [4].

The evolution of demographic variables in Romania is no exception to the general trend of European populations. Here, on one hand, birth rates, mortality, marriages have increasingly smaller values. On the other hand, the average age of marriage, at the time of the first marriage, the birth of the first child and the frequency of family dissolution, and of consensual unions is on increase.

In Romania, the structure on ages of the population bears the characteristic fingerprint of a demographic ageing process due mainly to the decrease in the birth rate (from 9.3‰ in the year 2013), which triggered the absolute and relative diminishment of the young population (0-14 years). In parallel, the increase in life expectancy (71.24 years for men and 78.28 years for women) determined an increase in the numbers and weight of elderly population (65 years of age and over).

We are witnessing a decrease in the weight of young population with ages between 0 and 14 years of age, from 23.6% (in the year 1990) to 14.86% (in the year 2013) and the increase in the weight of the elderly population with ages of 65 years and over, from 10,4% (in 1990) to 15.2% (in the year 2013). The adult population, with ages between 15 and 64 years, increased constantly from 66.03% (in the year 1990) to 69.97% (in the year 2013).

For the first time in the last four decades, as of January 1st, 2012, the weight of the young population became equal to the weight of the elderly population (15.0%). The elderly population is a heterogeneous entity, including the subgroup of 'younger' elderly (65 to 74 years of age), the 'older' elderly (75 to 84 years of age), and longevous old (85 years of age and over).

If, currently, from the 21.26 million inhabitants, 9.3 millions are adults, 5.7 million are young, youths and children, and over 6 million are elderly, and in 50 years the demographic image will look completely differently: pensioners will represent over half of the country's population, the numbers of adults and children will decrease, and the age pyramid shall narrow significantly its basis.

During the last years is noticed the trend of higher increases in the numbers of elderly which are in the subgroup 'older' elderly (from 816.7 thousands in the year 1990 to 1.206 millions in 2013), against the subgroup of 'younger' elderly (from 1.47 million in 1990 to 1.74 million in the year 2013).

The demographic ageing phenomenon is more marked in the rural area than in the urban area. Thus, at the beginning of 1990, the weight of the population aged 65 years and over in the rural area was of 13.5% from total population and increased in the year 2013 to 18.4%.

A characteristic of the demographic ageing process is the increase in the numbers of women in the group of elderly population, respectively a process of *"old-age feminisation"*. Women live longer, their numbers being almost twice as high as the numbers of men.

3. Analysis and forecast of the demographic evolution by Markovian techniques

The specialised literature includes an impressive number of various model-types by which is attempted to evaluate the stage at which population development is in a certain area. Among others, these models are used to determine the impact of the various factors on some indicators characteristic to the demographic phenomenon and, as well, to the forecast the short-, medium-, and even long-term population development [5] – [7].

3.1. Brief theoretic formulation of the Markov-type model for studying, analysing and forecasting the demographic phenomena

The probabilistic models are developed, in general, under two forms: a first category using the variable discrete 'time' and a discrete age scale and another category where time is a continuous variable just as the age scale.

In the stochastic model with discrete time, used for analysing and forecasting the demographic phenomenon, a series of assumptions are made, respectively:

- The census of the female population (called population *F*) is realised at discrete time intervals *n*=1, 2, 3...;
- This population is divided in *k* age groups, $k \in Z^*$;
- The number of women in the age groups at the time *n* is given by the random variable $\eta_n(j)$. As result, the moment and dispersion of the random variable becomes: $E\eta_n(j) = M_{j,n}$ and $D\eta_n(j) = D_{j,n}$
- If a member of the age group j at the time *n-1* gives birth to a girl at the time *n*, then the number of women in the age group 0 at the time *n* whose mothers were included in the age group *j*, is a random variable $\eta_n^{(j)}(0)$, with $\eta_n(0) = \sum_{j=0}^{k} \eta_n^{(j)}(0)$;
- The probability p_j that a person in the age group j at the time *n* will be in the age group $j+1$ after one unit of the time interval is fixed and for which $j < k$ is positive, and $p_k = 0$. These probabilities are presupposed as independent, thus, $q_j = 1 - p_j$;
- The probability b_j that a person in the age group j at the time *n* will give birth to a single girl in the time interval (*n, n+1*) and that this girl will be active in the group 0 at the time *n+1*, is fixed and these are assumed as independent. Thus: $d_j = 1 - b_j$
- The birth and death processes are assumed as independent;
- The changes in the male population structure are assumed as consistent with the assumptions of the constant measurements of fertility $\{b_j\}$;
- Multiple births are ignored.

In the case of a Markovian chain with the states 0, 1, 2,..., n, the transition probabilities are given by the relationship:

$$p(i, j) = C_n^j \left(\frac{i}{n}\right)^j \left(1 - \frac{i}{n}\right)^{n-j}, \quad 0 \le i, j \le n \tag{1}$$

The states – *0* and *n* – of the Markovian chain are absorbent.

The form of the transition probabilities given by the relationship (1) do not allow the direct calculation of the fundamental matrix of the chain, but give the possibility of identifying the general expressions of the transition probabilities in *n* steps, n>1.

If *i* is considered as a non-absorbent state, then, by virtue of the Chapman-Kolmogorov relationship, we obtain:

$$p(n,i,j)=\sum_{k=0}^{n}p(n-1,i,k)\;p(k,j)=\sum_{l=0}^{n-j}(-1)^{l}C_{n}^{j}C_{n-j}^{l}n^{-j-i}\sum_{k=0}^{n}p(n-1,i,k)k^{j+i} \tag{2}$$

And hence:

$$p(n,i,j)=\sum_{l=0}^{n-j}(-1)^{l}C_{n}^{j}C_{n-j}^{l}n^{-j-i}\,\mathbf{E}_{\mathrm{i}}(\,X^{j+l}(n-1)) \tag{3}$$

Which means that for determining $p(n,i,j)$ it is enough to know the first order moments *n* of the random variable *X(n-1)*.

If, also, for the suggested analysis is considered that:

- λ and μ are discrete random variables with integral positive values;
- $\lambda_1^{'}$ and $\lambda_2^{'}$ are random variables with binominal distribution $B(\lambda, p_1)$, $B(\lambda, p_1)$ and conditioned by λ.

Using the relationships: $\begin{cases}\mathbf{E}\lambda_1^{'}=p_1\mathbf{E}\lambda\\ \mathbf{D}\lambda'_1=p_1^2\mathbf{D}\lambda+p_1q_1\mathbf{E}\lambda\end{cases}$ (4)

with $\mathbf{E}_{\mathrm{i}}(\,X^{l}(n))=\mu_i^{l}(n)$

$$\begin{cases}\mathrm{Cov}\left[\lambda_1^{'},\lambda_2^{'}\right]=p_1p_2\mathbf{D}\lambda\\ \mathrm{Cov}\left[\lambda_1^{'},\mu'\right]=p_1p_3\mathrm{Cov}[\lambda,\mu]\end{cases} \tag{5}$$

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

$$\begin{cases}\mathbf{E}\eta_{n+1}(0)=M_{0,n+1}=\sum_{j=o}^{k}b_jM_{j,n}\\ \mathbf{E}\eta_{n+1}(1)=M_{1,n+1}=p_0M_{0,n}\\ \mathbf{E}\eta_{n+1}(2)=M_{2,n+1}=p_1M_{1,n}\\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\\ \mathbf{E}\eta_{n+1}(k)=M_{k,n+1}=p_{k-1}M_{k-1,n}\end{cases} \tag{6}$$

Using the relationships (4) and (5) is obtained:

$$\mathbf{D}\eta_{n+1}(j+1)=D_{j+1,n+1}=p_j^2D_{j,n}+p_jq_jM_{j,n}\;,j\geq 0 \tag{7}$$

$$\mathrm{Cov}[\eta_{n+1}(j+1),\eta_{n+1}(h+1)] = p_j p_h \mathrm{Cov}[\eta_n(j),\eta_n(h)] \quad , j, h \geq 0, j \neq h$$
$$\mathrm{Cov}[\eta_{n+1}^{(j)}(0),\eta_{n+1}(h+1)] = b_j p_h \mathrm{Cov}[\eta_n(j),\eta_n(h)] \quad , j \neq h$$
$$\mathrm{Cov}[\eta_{n+1}^{(j)}(0),\eta_{n+1}^{(h)}(0)] = b_j b_h \mathrm{Cov}[\eta_n(j),\eta_n(h)] \quad , j \neq h \qquad (8)$$
$$\mathbf{D}\eta_{n+1}^{(j)}(j+1) = b_j^2 D_{j,n}^2 + b_j d_j M_{j,n} \ , j \geq 0$$

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

$$\mathbf{D}\eta_{n+1}(0) = \sum_{j=0}^{k} \mathbf{D}\eta_{n+1}^{(j)}(0) + \sum_{j \neq h}\sum \mathrm{Cov}[\eta_{n+1}^{(j)}(0), \eta_{n+1}^{(h)}(0)] =$$
$$\sum_{j=0}^{k}\left(b_j^2 D_{j,n} + b_j d_j M_{j,n}\right) + \sum_{j \neq h}\sum \mathrm{b_j b_h Cov}[\eta_n(j), \eta_n(h)] \qquad (9)$$

And we obtain:

$$\mathrm{Cov}\left[\sum_{j=0}^{k} \eta_{n+1}^{(j)}(0), \eta_{n+1}(k+1)\right] = \mathrm{Cov}[\eta_{n+1}^{(j)}(0), \eta_{n+1}(h+1)] +$$
$$+ \sum_{j=0}^{k} \mathrm{Cov}[\eta_{n+1}^{(j)}(0), \eta_{n+1}(h+1)] = \mathrm{b_h} p_h D_{h,n} + \sum_{j \neq h} b_j p_h \mathrm{Cov}[\eta_n(j), \eta_n(h)] \qquad (10)$$

The equations (6)-(10) define completely the recurrence relationships for the average, variation, and co-variance of the sample subjected to the study. Under the matrix form they can be written as:

$$\begin{pmatrix} \mathbf{M}_{n+1} \\ \mathbf{V}_{n+1} \end{pmatrix} = \begin{pmatrix} \mathbf{A} & \mathbf{O} \\ \mathbf{B} & \mathbf{AxA} \end{pmatrix} \begin{pmatrix} \mathbf{M}_n \\ \mathbf{V}_n \end{pmatrix} \qquad (11)$$

Where the vector V contains variance and co-variance elements $D_{ij,n}$, and A is a Leslie, matrix defined by:

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

Thus we obtain the following relationship between variance and covariance: $\mathbf{V}_{[n]} = (\mathbf{A}x\mathbf{A})^n \mathbf{V}_{[0]} + \sum_{i=1}^{n} (\mathbf{A}x\mathbf{A})^{n-i} \mathbf{BM}_{i-1}$

By noting: $\boldsymbol{\mu}_i^{'}(n) = (\mu_i^1(n), ..., \mu_i^p(n))$, this relationship allows for the matrix writing:

$$\boldsymbol{\mu}_i^{'}(n+1) = \mathbf{C}\boldsymbol{\mu}_i^{'}(n) \quad (12)$$

with C diagonal matrix. As result,

$$\mathbf{E}_i\left(X^{j+i}(n-1)\right) = \mu_i^{j+l}(n-1) = \\ = \begin{cases} 1, & if \quad j = l = 0 \\ in^{j+l-1} + \sum_{r=2}^{n}\sum_{k=1}^{r} \lambda_r^{p-1} v_r(j+l) u_r(k) i^k, & j+l > 0 \end{cases} \quad (13)$$

where: $u_r^{'} = (u_r(1), ..., \mu_r(n))$ is the own vector to the left associated to the own value λ_r

$v_r^{'} = (v_r(1), ..., v_r(n))$ is the own vector to the right associated to the own value λ_r

Thus, for *j>0* is obtained, for the transition probabilities, the expression:

$$p(n, i, j) = \begin{cases} C_n^j \sum_{l=0}^{n-j} (-1)^l C_{n-j}^l n^{-j-i} \sum_{r=2}^{n}\sum_{k=1}^{r} \lambda_r^{p-1} v_r(j+l) u_r(k) i^k, & if \quad j \neq n \\ \frac{i}{m} + n^{-n} \sum_{r=2}^{n}\sum_{k=1}^{r} \lambda_r^{p-1} v_r(n) u_r(k) i^k, & if \quad j = n \end{cases} \quad (14)$$

3.2. Applying the Markovian model for studying the evolution and forecast of demographic phenomena

For the proposed analysis were used the data provided by the National Institute of Statistics [4] for the period 2007-2013 and other publications of the National Institute of Statistics with respect to the main demographic phenomena:

The database used comprises the following indicators:

- Romania's population on July 1st (yearly);
- population on large age groups;
- live births (in absolute data and as rates per 1000 inhabitants);
- deaths (in absolute data and as rates per 1000 inhabitants);
- still-born (in absolute data and as rates per 1000 inhabitants);
- deaths under the age of 1 year;
- the general fertility rate (number of children born by one woman during the entire fertile live span);
- population from the urban and the rural area;
- emigrants;
- immigrants;

The study of the evolution and forecast of demographic phenomena by the Markov's chains method implies several stages, respectively:

- the calculation of the considered indicators' structures;
- the calculation of the transition matrices (of transiting from one state to another). Each of the transition matrices calculated highlights the changes in the structure of each indicator from one year against the previous year;
- the calculation of the total transition matrix;
- the calculation of the transition probabilities matrix (transition);
- determination of the forecasted structure.

The analysis of the demographic phenomena was made for the historical period 2007-2013, and the forecast was realised for the period 2014-2017.

The analysis of the forecast by Markovian techniques highlights that after an increase in the birth-rates from 10.4‰ in the years 2009, a decrease takes place to 9.3‰ in the year 2013 and to approximately 9.2 ‰ in the year 2017.

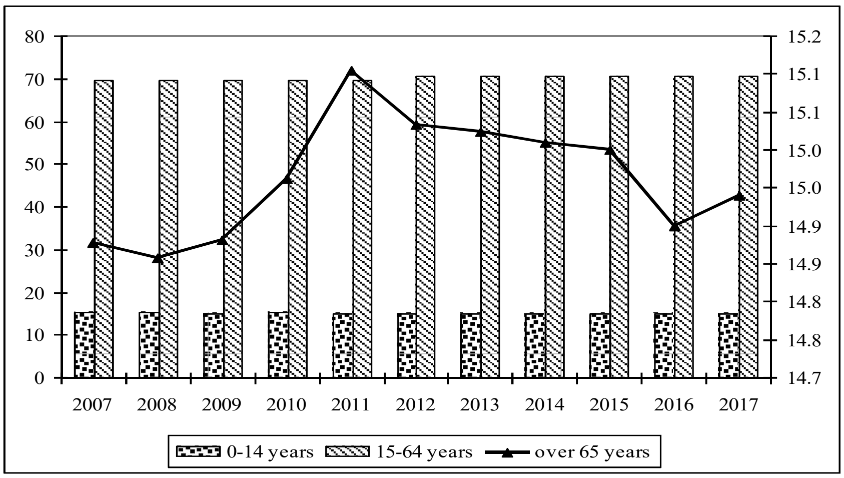
The analysis of the forecast by Markovian techniques of the indicator "general death rate" highlights that after a slight diminishment by 0.3 pp against the year 2012, this shall be placed for the forecasted period around the value of 11.4‰.

With respect to the stillborn rate is highlighted both for the historical period, and for the forecast one a decreasing trend. If in 2007 were registered 1009 stillborns, their number decreases in the year 2013 to 771, and in the year 2017 to approximately 700. Also in the case of the indicator "death under one year of age" the scenario realised by Markovian modelling highlights a decreasing trend, its weight in total population falling down from 12.0‰ in 2007, to 8.5‰ in 2013 and to 7.6‰ in the year 2017.

With respect to the evolution of the population on large age groups, in the historical period 2007-2013 a decrease by approximately 127.244

thousand persons takes place for the age group 0-14 years of age, of 24.814 thousand persons for the age group 15-65 years. Regarding the age group 65 years and over, an increase takes place by approximately 9.3 thousand persons in the year 2011, and after this time, the number of persons comprised in this age segment decreases (Figure 1). For the forecast period, decreases are registered for all population segments (Figure 1).

Figure 1. Population on large age groups, in the period 2007-2013 and forecasted values for the period 2014-2017, (%)



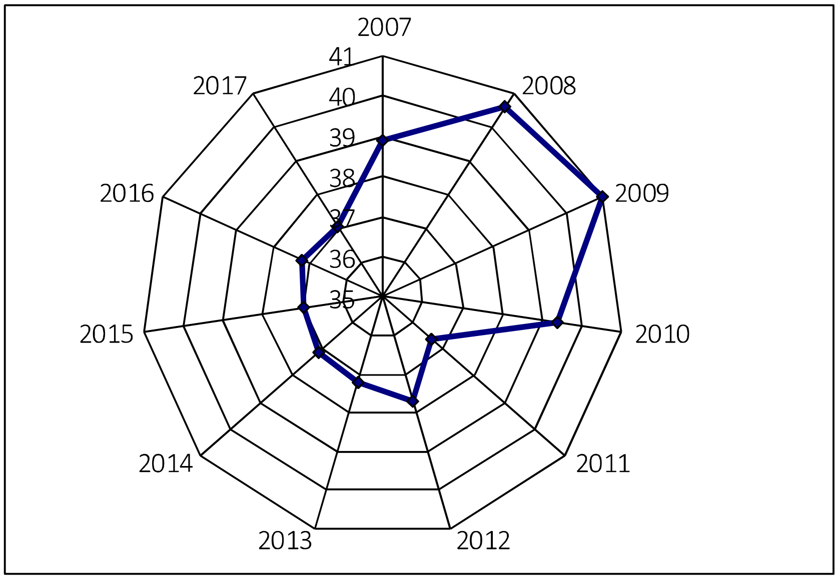
Source: historical data: Romania's Yearbook 2007-2013, forecast realised by author

This fact indicates that, on short-term, the ageing process of Romania's population shall continue. To this will contribute also the structure of the migration flows in the forecasted period.

As exogenous variables in the model information was included related to the numbers of migrants and immigrants, but because the historical data regarding their evolution are found only in official bulletins, the forecasted outcomes about the future evolution of these indicators of population movement should be considered just from qualitative and not from a quantitative viewpoint.

Regarding the general fertility rate (the number of children born by a women during the fertile life span) for the period 2007-2013 it has an oscillating evolution, with a maximum of 41% in 2009 (Figure 2), followed by a decrease up to the year 2011, and thereafter a slightly increasing trend can be registered.

Figure 2. Evolution of the general fertility rate, in the period 2007-2013 and values forecasted for the period 20014-2017



Source: historical data: Romania's Yearbook 2007-2013, forecast realised by author

The variance of this indicator for the forecasted period is oscillating.

Conclusions

Nowadays, the concerns with respect to demographic evolution re-emerges due to the risks it could give birth to in generating some local, regional, continental or planetary crises that could influence negatively the social order and could lead to triggering disturbances of the ethnic or religious balance.

In the current context, the phenomenon of demographic ageing, and the one of the extended economic crisis with resonance with respect to the sustainability of the pension systems, to the level of public pensions for several generations, the impact on the individual welfare is multiplied at the level of vulnerable group.

The reasons of these evolutions are first, the low fertility rate by which the parents' generation is replaced only partially, followed by migration and in particular, external migration affects mostly the youths with high skills level.

The non-linear models allow for a more accurate description of the impact of some factors like, for instance, the fertility rate, the birth rate, the death rate, or migration one on the demographic development and, implicitly, on the ageing phenomenon of Romania's population.

The demographic analyses and forecasts on short-, medium- and long-term may be used in substantiating consistently the development plans and strategies. Demographic changes of the last decades represent an increasingly higher concern at European and national level, the decision factors at the highest levels becoming aware about the amplitude of these phenomena, and about the importance of knowing them for the future evolution of the societies.

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