6. EXCHANGE MARKET PRESSURE AND DE FACTOTHE EVOLUTION OF DEMOGRAPHIC PHENOMENA IN TERMS OF GLOBALIZATION AND ENVIRONMENTAL CHANGES[1]

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Abstract

Globalization, climatic changes and demography are the main forces modeling the development of societies, in general, and of each nation, in particular. Both offer opportunities but also imply challenges.

The paper aims to identify and synthetically present some factors of influence which triggered by the end of the 20th century and the beginning of the 21st century a series of characteristics defining the changes in the demographic model and structure of population by age brackets. Romania's population lost in the period 1992-2007 about 1250 thousand persons.

Also, this paper presents the most important factors that determined the demographic decline beginning in the last decade of the 20th century at national level. For Romania, another phenomenon was represented by the demographic implications of the emigration of the female population of fertile age. The increasing share of female population in the emigration flows became more noticeable over the period 2002-2007.

The paper presents the results obtained by using the Markov model for studying the development of demographic indicators in Romania, and their forecasting as well.

Keywords: globalization, climate changes, demographic evolution, socio-economic impact, demo-economic factors, models, Markov models

JEL Classification: C13, C15, C32, C35, J12, J13, Q52, Q54, Q59

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1. Introduction

The intensified globalization represents the fundamental feature of the world economy at the beginning of the 21st century. Globalization is characterized by the marked trend of diminishing and eliminating the barriers between the national economies, as well as by stronger links between these economies.

Globalization involves multiple processes that are inter-conditioned and on a wide scale. Within the policies and strategies of globalization, they generated and developed certain dimensions, yet not all of them were defined and formalized accordingly.

Globalization has, as well, its own *demographic model*: swift acceleration of individuals' movement from the rural area and the agrarian lifestyle to the urban areas, which is more closely related to the global trends in fashion, food, markets and leisure.

Globalization and demography are the two main forces modeling the development of societies, in general, and the European one, in particular. Both offer opportunities and imply challenges as well.

The demographic trends at world level and, implicitly, at European level, indicate longer and healthier life spans and question topics such as the new costs of an aging society, equity among generations, the higher importance granted to child nurturing and to the work/personal life balance in fostering family life, the relationships between generations and the new poverty threat.

The disruption of natural balances due to global warming will lead, in the best case, to a crisis not encountered since World War II. Assessment studies with respect to the impact of climate changes on the economic development, but especially on the population evolution on long term are only beginning nowadays to gain outlines.

The Third Conference of the Parties developed in December 1997 in Kyoto, Japan, was a new step ahead regarding the issue of climate changes from a global perspective. The presented scientific evidences indicated the need of more stringent measures for diminishing the greenhouse gas emissions.

Just as globalization and demography are two main forces shaping the development of societies, in general, and of the European one, in particular, the climate changes are the ones determining the future evolution of both demography and globalization.

Globalization, next to new technologies, provides a huge growth potential. Yet, individuals should be able, due to their studies and professional training, to take full advantage of these opportunities and adjust to the disappearance of some traditional industrial trades.

The paper intends to analyze the impact of environmental changes and of globalization on the development of the main demographic phenomena.

2. Globalization impact on demographic phenomena

In the last decade, the world's economic map was redesigned, both because of the spectacular changes occurred on the international political scene and of the influence of unprecedented technological shifts. A certainty is that the market economy triumphed all over the world. On the background of these substantial changes the basic trends were emphasized. One of them refers to the economic globalization advantaged, among others, by the diminution in transportation costs and by communication.

The other confirms the attempt of various nations, connected to their own territory, to organize within some regional frameworks defined by geographical and historical proximity connections. In this new context, the power relationships changed under the influence of shifting the heavy weight of world output, meaning the localization of the latter, determined in its turn by the strategic games implemented mostly by multinational companies acting at present under the power of attraction of national territories.

2.1. Characteristics of world demographic evolution

Despite the array of production and consumption models, the world economy is far from being homogenous.

If the earth's population continues to grow at the current rate, then mankind shall face soon a critical issue generated by the imbalance that might appear between producers and consumers. The signs of such an imbalance may be felt already, representing one of the most spectacular shifts about to change radically the appearance of the world in which we live.

As it is already known, for a long time Asia-Oceania represented more than half of the world population. This impressive increase triggered a shift in the output heavy weight and reversed the relative levels of economic development without the respective micro-region gaining the expected position in the distribution of the world income. As of 1960 and up to 1999, the world population exceeded 3 billion and increased to 6 billion inhabitants, and in 2009 it is of 6.829 billion inhabitants. Unfortunately, the territorial distribution of this population is extremely unequal. For instance, in the year 2009 in Asia there were less than 4.21 billion people, that is 60.35% of the world population. Europe did not succeed to total more than 10.72%, while Africa had 14.8%. Smaller shares were held by Latin America and the Caribbean (8.52%), North America (5.1%), and Oceania (0.51%).

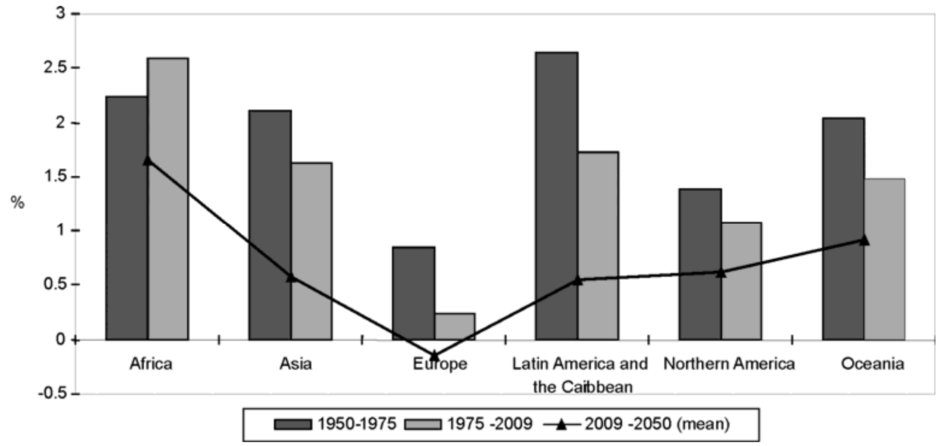
In accordance with the data provided by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2009), *World Population Prospects: The 2008 Revision*, the world population in 2009 numbered 6.829 billion persons, against 4.1 billion in 1975, 4.8 billion in 1985, 5.3 billion in 1990, and 5.71 billion in 1995.

According to the World Bank Report, the average rates of world's population change in the major areas for the periods 1950-1975, 1975-2009, were distributed in accordance with Figure 1.

The most recent estimates about population made by the UN indicated that the demographic increase at world level should be 1.8% over the period 2005-2010, and thereafter it would decrease to 0.34% over the period 2045-2050, considerable diminutions being recorded also for the major continents (Figure 2). The most dramatic situation with respect to the natural increase is highlighted for Europe where, if in the period 2005-2009 a negative value (-0.09%) was recorded, for the period 2045-2050 the forecast would be of -0.40% (Figure 2).

Figure 1

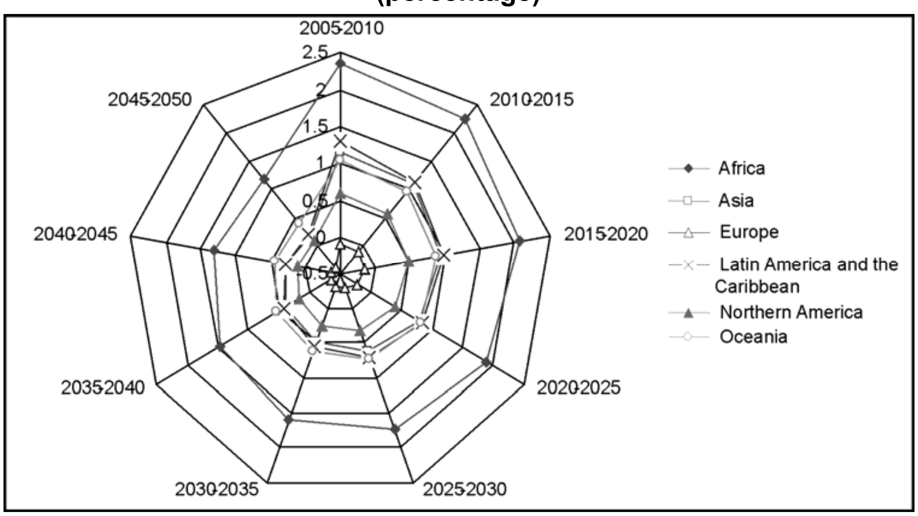
Average Annual Rates of Change of the Population in Major Areas, 1950-1975, 1975-2009, 2009-2050 (mean)



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2009). World Population Prospects: The 2008 Revision. Highlights. New York: United Nations, and author's computations.

Figure 2

Average Annual Rate of Natural Increase in Major Areas, 2005-2050 (percentage)



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2009). World Population Prospects: The 2008 Revision. Highlights. New York: United Nations, and author's computations.

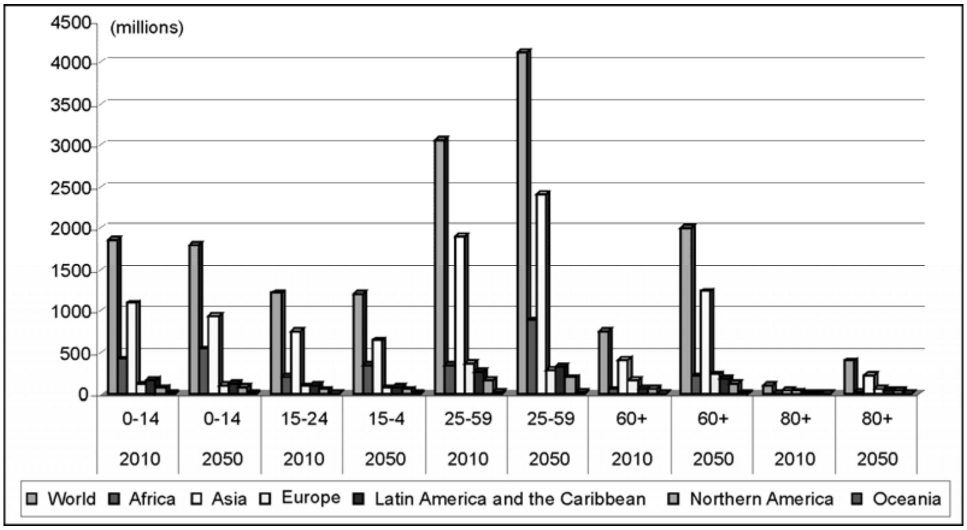
Considering the sustainability limits of the financial and geographical systems of each country, all national governments require a carefully elaborated and adequately supported demographic policy that should take into account the hosting capacity of the country, irrespective of the consumption level decided by the citizens. As noticed by Edward O. Wilson, biologist at Harvard "*each nation has an economic policy and a foreign policy. The time has come to talk more openly about a demographic policy...which is in the vision of the informed general public, the optimum population?*"

The analysis of some statistics and scenarios realized by various international bodies allows for inferring some conclusions, namely:

a) Population distribution on earth will continue to be uneven, the Asian region counting on about 57.2% of the world population in 2050 (it was 60.5% in 1995 in the median variant of the UN estimates), followed by Africa with 21.8% (12.7% in 1995).
b) The People's Republic of China remains also in the future by far the most populated country of the world, with 1.22 billion inhabitants in 1995, and the forecasts indicate a population growth to 1.45 billion in 2025 and to 1.417 billion in 2050. If by 2025 India maintains its second position by 1.431 billion inhabitants (as compared to 936 million inhabitants in 1995), in 2050 its population will reach 1.614 billion inhabitants, hence moving up to the first position. Still, the highest growth rate of population in the world is forecasted to be recorded in Africa.
c) The lowest population growth rate will be recorded in Europe, the population of which, in 2025, will practically be maintained at the level of the year 1995 (727 million persons). In 2050, the total fertility rate (the average number of children per woman) will be in the average scenario the lowest also in Europe (1.82) and the highest in Africa (2.4).
d) With regard to population distribution by age groups, the data delivered by the UN Report of the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2009) highlight a general aging of the population. Thus, at world level, the population aged 60 years and over will be 759 million persons in 2010, and 2008 million in 2050. The same phenomenon will be recorded also for the age group of over 80 years: 106 million persons in 2010 and 395 millions in 2050 (Figure 3).
e) With respect to the age groups 0-14 years and 15-24 years, in Asia, Europe and in Latin America and the Caribbean as well the period 2010-2050 will record a diminution of these population segments. For the 25-59 age group, only in Europe population decreases corresponding to this population segment will be recorded (Figure 3).
f) The analyses indicated the fact that population diminutions in 2050 will be recorded only in Japan (the population will decrease by about 25497 thousands persons), in the Russian Federation (by approximately 24777 thousands persons), in Germany (by about 11663 thousands persons) and in the former communist countries of Europe.

Figure 3

Distributions of the Population of the World and Major Areas by Broad Age Groups, 2010 and 2050 (Average Variant)



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2009). World Population Prospects: The 2008 Revision. Highlights. New York: United Nations, and author's computations.

3. The impact of environmental changes on demographic developments

The collapse of natural balances because of the global warming will lead, in the best case, to a crisis not encountered since the end of the World War 2. Evaluation studies for the impact of climate changes on the economic evolution on long term are just beginning to take shape.

To the contrary, ignoring the climate changes will affect economic growth. The carbon emissions of the power sector should be diminished by at least 60% up to 2050 in order to succeed in stabilizing the carbon concentration in the atmosphere below 550 ppm. Also, a substantial diminution should be obtained also in the case of the emissions generated by the transportation sector.

Experts of the Intergovernmental Group on the Climate Evolution published a report which maintains that 90% of the human activity has generated severe disturbances in the world's ecosystem. The rather alarming scenario supported by the experts reunited in Paris suggests that the temperatures shall increase to a worrying level in the following years. The effects of climate changes could be devastating for the entire mankind.

Sharing the same opinion, a report of the World Health Organization (WHO) shows that the changes generated by mankind with respect to the earth's climate would have as a result the yearly death of more than 150.0 thousand persons and the illness of at least five million people. One of the predictions will be that, by the end of the century, a temperatures increase of up to 6.3 degrees Celsius might occur, although the most probable interval will be between 2 and 4.5 degrees.

3.1. Aspects relevant for limiting climate changes and diminishing the energy intensity in Romania as compared to the European Union countries

Sustainable economic growth requires additional lower power consumption, mainly due to structural changes within the economy. In reality, this it does not happen, since the economic progress is often accompanied by increases in the total power consumption which is mainly obtained from conventional primary resources (oil, coal, natural gas).

From recent analyses performed about the progress made for sustainable development in Europe, it resulted that in the last decade of the last century a significant diminution was recorded with respect to the greenhouse effect emissions (GE), mainly as result of shifting to fuels with lower carbon content and replacing coal heating with more efficient fuels in combination with an increased co-generation. Decoupling economic growth from the gross internal power consumption is one of the main objectives of the sustainable development strategy of the European Union.

The data of the analyses indicate unequal progresses with respect to decoupling. After 2000, the GE emissions have increased on average by 0.3% within the EU-15 and by 0.6% within the EU-25.

Regarding Romania, the country is placed on an ascending trend of intensive energy consumption. In the last years, the gross internal energy consumption recorded an increasing trend, with an annual average of 1%, especially due to an increased coal demand (including here coke). About diminishing the GE emissions, this trend is not positive. However, the total net GE emissions decreased by about 50% as compared to 1989, as a result of the drastic diminutions of industrial output and of the economic restructuring during the years of transition to the market economy.

By comparing the energy consumption with the economic growth for the last years, it can be found that it was outpaced by the economic activity.

Even though the situation in Romania is far behind the European schedule, the statistical data suggest an improvement regarding the energy intensity. Against the EU-25 average of energy consumption, of 175 tons oil equivalent (TOE) for one million GDP (PPS), Romania recorded a level of 272 tons oil equivalent for one million GDP (PPS), being in a better position than Iceland (473), Bulgaria (392), Estonia (370), Slovakia (319), etc. The lowest levels of energy intensity were obtained in Italy (132), Ireland (138), Denmark (144), Austria (148), the United Kingdom (154), etc.

In the case of Romania, the increase in the energy intensity of economic growth under the circumstances of diminishing the GE emissions represents a challenge, taking into account the international context, the requirements for European integration and the domestic adjustment possibilities. The increase in eco-efficiency requires both obtaining environmental performance and improving the economic performances. The diminution of gaps against the EU requires the replacement of obsolete and polluting technologies with some that are better performing and cleaner, as well as a series of measures aimed at the environmental policies based on market mechanisms. The necessary changes in the production and consumption models need not only an increase in the products with ecological labels, but also in the knowledge and participation level of the civil society and of the business sector in developing and enforcing the decisions about environmental protection.

Romania is part to implementing some flexible mechanisms as provided by the Kyoto Protocol, such as the Joint Implementation – JT and the International Emission Trading – IET, which ensure a series of opportunities and advantages for complying with national and international assumed commitments.

Within the National Strategy on Climatic Changes (NSCC), elaborated in Romania as a result of sharpened issues regarding the GE, is provided for the principles and implementation of the Emission Trade Scheme of the EU. Even though the NSCC was intended for the period 2005-2007, drawing up the strategy for a wider time horizon was taken into account, up to 2012 when the first period related to the Kyoto Protocol commitments will be concluded.

By GE trading within the EU, the following effects are aimed at in Romania: i) participation of an important number of economic agents from the energy and industry sectors to emission trading which shall become a supplementary income source by selling additional permits; ii) the direct evaluation from an economic viewpoint of the aspects related to GE diminution; iii) the introduction of international standards with respect to the GE pollution.

By its contents, the NSCC is a useful document for the convergence of the environmental policy towards the major objective of achieving sustainability of development and, implicitly, of the demographic development.

4. Models for the analysis of the impact of environmental changes and globalization on demographic evolutions

In the specialized literature various models are used to determine the impact of globalization and of climate changes on the demographic evolution. These models are used for quantifying the evolutions of the socio-economic development of some countries at different levels of endowment with natural resources, material and human capital, technology and population, in a world with a particular dynamics of goods, persons, and capital movement, with flexible structures of the economies, etc.

By means of the developed scenarios it is intended to quantify the impact of globalization on various countries depending on the actual conditions of the respective country. Within the model, the following important segments are included: i) the global economic system; ii) the system of the natural environment resources, referring to the environment quality, the capacity of the natural resources to ensure welfare to the output and consumption within the economy; iii) the changes triggered by the population increase and its distribution by age groups in each country taken into account (including here also the international migration).

The consequence, determinism and discrete time periodicity of the model is followed by means of: i) equilibrium; ii) optimization (maximizing profit, maximizing wage by international migration, mixed final consumption of goods, mixed investments, etc.); iii) updating (in production, numbers and structure by age groups of population, mortality and fertility rate, etc.).

To these, a set of information about the price indexes of the international trade is added.

In general, the models used for this purpose includes several modules, respectively:

- *production module*, comprising three sectors of production: the industry of intensive resources (generating finished goods), non-intensive resources industry (services), and extracting industry (and generating intermediary goods).
- investment module;
- *environmental quality module*; within this module the air pollution and the impact of polluting spillages at local and regional level are taken into account. It is pursued to obtain information on the evolution of the emissions resulting from the economic activity, and, to a lesser, extent information about the economy's structure. Pollution is a result of used energy sources, which are assumed within the module to be a linear function of production in the intensive resources industry, and as a logarithmic function depending on the end consumption of goods per capita.
- *population module,* which comprises the basic demographic indicators, as well as the indicators related to the migration flows.

4.1 Brief presentation of the demographic characteristics of Romania

The political, economic and social changes which Romania underwent after December 1989 left a heavy imprint on the population's evolution and on the demographic phenomena. The swift and significant decrease in the birth rate, the recrudescence of mortality and negative external migration of unknown size have all dramatically changed the demographic landscape in Romania.

The year 2008 is the 19th year of demographic decline, a period in which Romania lost almost two million inhabitants, which means 8% of the population recorded in early nineties.

The evolution of demographic variables in Romania makes no exception from the general trend of the European populations. Here, on the one hand, birth, mortality and marriage rates record more and more decreasing values. On the other hand, the average age at the time of the first marriage, the birth of the first child and the frequency of families' dissolution and consensual unions is increasing.

Yet, what differentiates European populations are the rate at which these developments take place and the depth of the changes. As a result, they are differentiated also by the swiftness and amount of the social problems triggered by these developments. Hence, in influencing them, the socio-economic determinism is very important.

The decrease in Romania's population is triggered particularly by the low fertility rate (1.3 children per woman, instead of 2.1 which would ensure the replacement rate) and by the high external migration rate (approximately 2 million Romanians are legally established abroad and the number of those illegally emigrated is unknown).

Additionally, if we take into account also the potential loss of young population as a result of the emigration of women of fertile age, then we may appreciate that the total potential negative balance of population could be doubled (emigration, adding to it the number of children that could have been born if the women remained in the country). Over the period 2002-2007, the share of women in the total emigrated population was about 70%, and the number of possible children to be born at a fertility rate of 1.3 children per woman would have represented 90% of the total effectively emigrated population in that period (about 10 thousand persons per year).

If we assume that only two-thirds of the emigrated women would give birth to at least one child, the annual numbers with respect to population loss by births abroad would vary between 3879 persons in 2002 and 7714 persons in 2006, the year with the highest level of emigration since the beginning of the present century (14197 persons in total, of which 62.4% were women).

Yet, at the same time Romania records an average mortality rate and increased life expectancy which trigger a significant population aging. If, currently, from the 21.6 million inhabitants, 10.5 millions are adults, 5 million young persons and children and 6 million are aging persons, over 50 years the demographic picture will be completely different: pensioners will account for more than half of the country's population, the number of adults and children will decrease and the age pyramid will significantly narrow its basis.

The latest data available about Romania provided by the National Commission for Prognosis show that the employment rate of working age population (15-64 years) was 40.9% in 2008 and estimated to decrease to 40.6% in 2009 under the circumstances of the financial crisis, a trend that is against the revised Lisbon Strategy targets. Additionally, the employment forecast of working age population shows a decreasing trend, the total working age population being estimated at 14974 thousand persons in 2013 as against 15046 thousand persons in 2007, which represent a loss of 72 thousand persons.

In other words, the is a danger of severe demographic imbalance of the country, which triggers severe economic and social imbalances: on the labor market, within the pension system, in the health services, in education and in the general social protection system, as well as in the budgetary income and expenditure system, etc. As a determinant factor for defining and structuring a viable strategy for sustainable development of the country, population must remain the core element upon which the entire attention of the decision factors, as well as the attention of the entire Romanian society, should be focused.

4.2. Analysis and forecast of the evolution of demographic phenomena using the Markovian techniques

4.2.1. Brief theoretical formulation of the Markov-type model

Initiated by Markov, the use of the dependence called after him in the shaping of some real phenomena saw after World War II a proliferation hard to imagine; given the wide range of uses of the Markovian chains they have known an explosive increase in their use in the science about mankind and issues challenging it: demography, theory of social mobility, education systems, ecology, pollution, biology and medicine.

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

In the stochastic model with discrete time used for the analysis and forecast of the demographic phenomenon, a series of assumptions are made, such as:

- the census of female population (called population *F*) is made on discrete time intervals, *n*=1, 2, 3...;
- This population is divided into *k* age groups, $\mathrm{k} \in Z^*$;
- The number of women by age groups, at the time *n* is given by the aleatory variable $\eta_n(j)$. As a result, the moment and dispersion of the aleatory variable becomes: $\mathrm{E}\eta_n(j) = M_{j,n}$ and $\mathrm{D}\eta_n(j) = D_{j,n}$
- If a member of the age group j at the time *n-1* gives birth to a girl in the time *n*, then the number of women in the age group 0 at the time *n* whose mothers were in the age group *j* is an aleatory 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 a unit of the time interval is established and for which $j < k$ is positive and $p_k = 0$. These probabilities are assumed as independent, hence $q_j = 1 - p_j$;
- The probability b_j that a person in the age group *j* at the time *n* gives 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 established and these are assumed as independent. Hence: $d_j = 1 - b_j$
- birth and death processes are assumed as independent;
- the changes in the male population structure are assumed to be consistent with the assumptions of the constant measurements of fertility $\{b_j\}$;
- multiple births are ignored.

In the case of a Markov chain with the states 0, 1, 2,...n, the shifting 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 Markov chain are absorbent.

The shape of the shifting probabilities given by the relationship (1) do not allow for the direct computation of the fundamental matrix of the chain, but offer then the possibility of identifying the general expressions of the shifting possibilities in *n* steps, *n>1*.

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

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

Which signifies that, in order to determine $p(n,i,j)$, it is enough to know the prime moments of order *n* of the aleatory variable *X(n-1)*.

Also, if for the suggested analysis it is considered that:

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

By using the relationships:

$$\begin{cases}\mathbf{E}\lambda_1^{'}=p_1\mathbf{E}\lambda\\ \mathbf{D}\lambda'_1=p_1^2\mathbf{D}\lambda+p_1q_1\mathbf{E}\lambda\end{cases} \quad (3)$$

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

$$\begin{cases}\mathrm{Cov}\left[\lambda_1^{\prime},\lambda_2^{\prime}\right]=p_1p_2\mathbf{D}\lambda\\ \mathrm{Cov}\left[\lambda_1^{\prime},\mu'\right]=p_1p_3\mathrm{Cov}[\lambda,\mu]\end{cases} \quad (4)$$

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

$$\begin{cases}\mathbf{E}\eta_{n+1}(0)=M_{0,n+1}=\sum_{j=o}^{k} b_j M_{j,n}\\ \mathbf{E}\eta_{n+1}(1)=M_{1,n+1}=p_0M_{0,n}\\ \mathbf{E}\eta_{n+1}(2)=M_{2,n+1}=p_1M_{1,n}\\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\\ \mathbf{E}\eta_{n+1}(k)=M_{k,n+1}=p_{k-1}M_{k-1,n}\end{cases} \quad (5)$$

Using the relationships (3) and (4) we obtain:

$$\mathbf{D}\eta_{n+1}(j+1)=D_{j+1,n+1}=p_j^2D_{j,n}+p_jq_jM_{j,n}\ , j\geq 0 \quad (6)$$

$$\mathrm{Cov}[\eta_{n+1}(j+1),\eta_{n+1}(h+1)]=p_jp_h\mathrm{Cov}[\eta_n(j),\eta_n(h)] \quad , j,h\geq 0,\ j\neq h \quad (7)$$

$$\mathrm{Cov}\left[\eta_{n+1}^{(j)}(0),\eta_{n+1}(h+1)\right]=b_jp_h\mathrm{Cov}[\eta_n(j),\eta_n(h)] \quad , j\neq h$$

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

$$\mathbf{D}\eta_{n+1}^{(j)}(j+1)=b_j^2 D_{j,n}^2 + b_j d_j M_{j,n} \ , j \geq 0$$

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

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

and we obtain:

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

The equations (5)-(9) completely define the relationships of recurrence for the average, variance and co-variance of the sample subject to the study. In a matrix form they could be written as:

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

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

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

Hence, we obtain the following relationship of variance and co-variance:

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

Observing: $\boldsymbol{\mu}_i^{'}(n)=\left(\mu_i^1(n),...,\mu_i^p(n)\right)$, this relationship allows for writing it as matrix:

$$\boldsymbol{\mu}_i^{'}(n+1)=\mathbf{C}\boldsymbol{\mu}_i^{'}(n) \quad (11)$$

with ***C,*** a diagonal matrix.

As a result:

$$\mathbf{E}_i\left(X^{j+i}(n-1)\right)=\mu_i^{j+l}(n-1)=\begin{cases}1, \quad daca \quad j=l=0\\ in^{j+l-1}+\sum_{r=2}^{n}\sum_{k=1}^{r}\lambda_r^{p-1}v_r(j+l)u_r(k)i^k, \quad j+l>0\end{cases} \tag{12}$$

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

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

Hence, for *j>0* for the shifting probabilities we obtain the expression:

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

4.2.2. The Markov model applied to the study of demographic phenomena evolution and forecast

In order to study and forecast the evolution of demographic phenomena in Romania by Markovian methods, we used the data from the Statistical Yearbook of Romania 2000-2008 and from other publications of the National Institute of Statistics regarding the evolution of major demographic phenomena.

The used database includes: Romania's population (on July 1st annually), population by age group, live births (in absolute data and rate per 1000 inhabitants), deaths (in absolute data and rate per 1000 inhabitants), born dead (in absolute data and rate per 1000 inhabitants), deaths at an age under 1 year, general fertility rate (number of children born to a woman during her fertile life), urban and rural population, emigrants, immigrants.

The study of evolution and forecasting demographic phenomena by means of the Markov chains method involves several steps, namely: the calculation of the structures of considered indicators, the calculation of transition matrices (crossing from one state to another) - each calculated transition matrices highlights the changes in the structure of each indicator in a given year over the previous year -, the calculation of the total transition matrix, the calculation of transition probability matrix (transition), determination of expected structure.

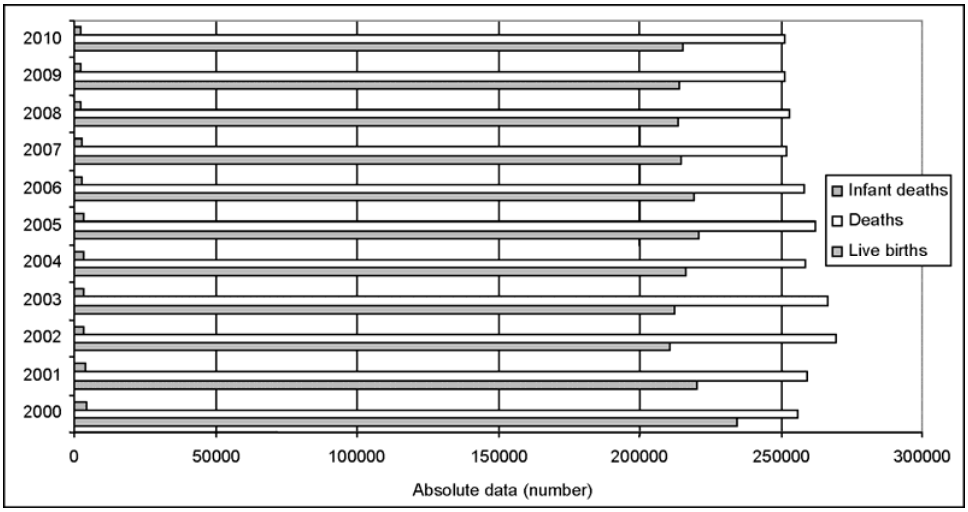
The analysis of demographic phenomena was done in the historical period 1990-2007, and the forecast was made up to 2010 (the forecast using the Markov chain proved to be correct only for short periods of 2-3 years[2]).

The historical evolution and the projected values for the indicators birth rates (live births per 1000 inhabitants), overall mortality rate (deaths per 1000 inhabitants), the mortality rate at birth (born dead to 1000 inhabitants) and deaths under 1 year in 1000 live births are shown in Figure 4.

[2] *See "The Markovian models used to study the evolution of some macroeconomic indicators", in* Nonlinear Approaches to Economic Processes*, pag. 103-120, Editura Expert, 2009.*

Figure 4

The evolution of some indicators of population during 2000-2010



Historical data source: Statistical Yearbook of Romania 2000-2007; for other years, see the author's calculations.

The analysis of the projection using Markovian techniques highlights that after an increase in the live-births rate to 10.2 ‰ in 2005 and 2006, they decreased to 10 ‰ in 2007 and recorded again a slight increase at the beginning of 2008. The birth rate reached nearly 10.6 ‰ in 2010.

The comparative analysis of the results through Markovian techniques for this indicator with the results projected by the Center for Demographic Research (CDR)-NIER of the Romanian Academy underpin insignificant differences, if the scenario of an average forecast against these is taken into consideration.

Thus, the CDR forecast, according to the average version, projects that the population in 2010 will reach 21641 thousand persons and the number of live births will be 202.1 thousand persons. By Markovian techniques applied for the same year, the population will reach 21510.154 thousand persons and the number of live births will be 215.9 thousand persons.

The analysis of the forecast using Markovian techniques for the indicator "deaths rate" points out that after an increase to 11.7 ‰ in 2007, it decreased to 11.49 ‰ in 2010 (12.6 ‰ determined by the Center for Demographic Research in the average scenario). In absolute data, this means that, for example, in 2010 the number of deaths should be 251.6 thousand.

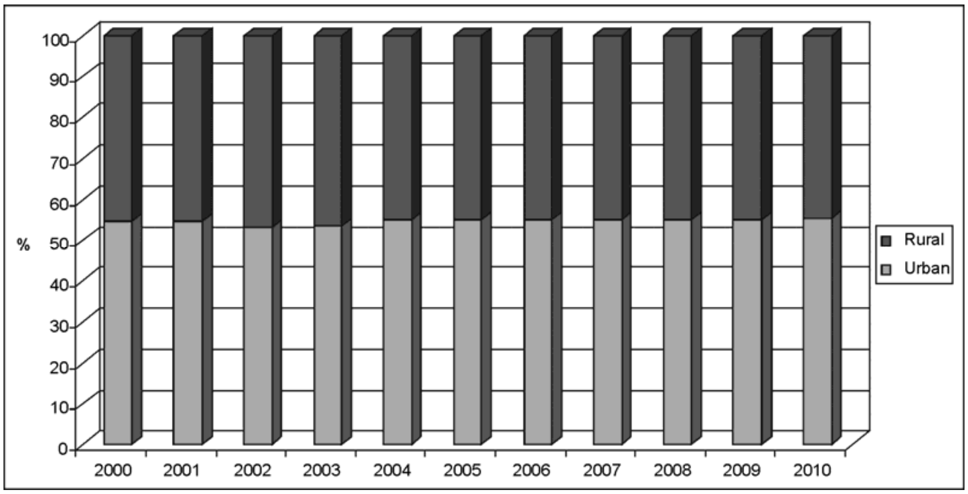
In terms of death rate at birth, applying the same technique for both the historical and the forecast period shows a downward trend. If in 1990 the record was of 2231 born-dead, the figure decreases to 1009 in 2007 and to 835 in 2010.

For the indicator "infant deaths per 1000 live-births" the scenario developed according to the Markovian model highlights a downward trend, its share in total population decreasing from 0.036% in 1990 to 0.012% in 2007, and to 0.0113% in 2010.

In 1997, a population growth in urban areas was recorded (among others, also a as result of the opening of the main cities), reaching 55.02% of the total population, after which the process was reversed, the share of the population in urban areas in total population decreasing to 53.26% in 2004 (Figure 5).

Figure 5

Structure of population by areas during the period 2000-2010



Historical data source: Statistical Yearbook of Romania 2000-2007; for other years, see the author's calculations.

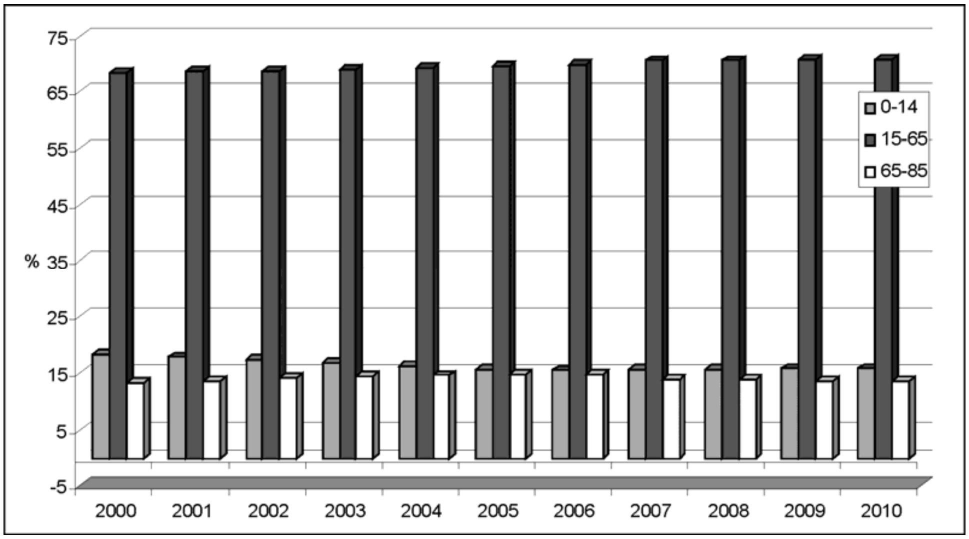
Since 2004, an increase in the share of population in urban areas has been underpinned, reaching 55.19% of total population in 2006. Also, for the period 2007-2010 the results of the evolution of urban population shows small oscillations of the respective share in total population (Figure 5), but with a general ascending trend, and in 2010 it will be 55.4%.

The population of rural areas (Figure 5) is complementary to urban population, and as the scenario develops it will represent 44.6% of the total population in 2010.

Regarding the evolution of large population age groups, over the historical period 2000-2007, a decrease of approximately 809.641 thousand people in the 0-14 years age group, of 302.210 thousand people in the group aged between 15 and 65 years, and an increase by around 372.5 thousand people in the group aged between 65 and 85 years were recorded (Figure 6).

Figure 6

The population by age during 2000-2007 and forecast values for the period 2008-2010



Historical data source: Statistical Yearbook of Romania 2000-2007; for other years, see the author's calculations.

For the forecast period, the segment of the population aged 0-14 registered a slight increase in 2007, a trend that is maintained during the forecast period. Thus, in 2010 the population aged between 0 and 14 will represent approximately 15.75% of the total population (Figure 6).

The evolution of the trend of this segment of the population determined by Markovian techniques is the same as that obtained by CCD, both in the lower and the average forecast variant.

In the segment of the population in the age groups between 15 and 65 years of age, both the historical and forecast periods highlight an increasing trend. In 2007, it represented 70.56% of the total population of the country, and in 2010 it will be about 70.72% (Figure 6).

The number of the individuals with ages between 65 years and over revealed during the historical and forecast period an oscillatory evolution, but with a general ascending trend. After a slight decrease in the numbers of this segment of population in 2007, to 2613.013 thousand people as compared to 3191.446 thousand registered in 2005, it will reach a value of 2900.934 thousand in 2010 (Figure 6). This indicates that both on short and medium term the ageing of the Romanian population will continue.

To the ageing of the Romanian population will contribute the structure of migration flows for the forecast period, as well.

As exogenous variables in the model were included the information on the number of emigrants and immigrants, but historical data regarding their evolution were available only in official bulletins, so that the forecast of the future evolution of these indicators of population movement must be considered from a quality viewpoint and not from one regarding quantity.

In terms of overall fertility rate (number of children born to a woman during her fertile life), during 1998-2002, a decreasing trend was revealed, with a marked "drop" in the period 2000-2002, followed by an even more noticeable increase in 2003-2006, while thereafter a moderate growth could be observed.

In the current situation, 2007 reveals a diminution from 39.6% in 2006 to 38.9% in 2007, a trend underpinned by the forecasting scenario.

Using Markovian models to analyze and forecast demographic indicators can provide useful information to government bodies in developing policies and decisions with respect to population growth, employment, etc.

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