Analysis and forecast of employees' mobility on the labor market in Romania using Markov chains

Mariana BĂLAN, PhD
Institute for Economic Forecasting - NIER, Romanian Academy and
"Athenaeum" University – Bucharest
mariana_prognoza@yahoo.com

Carmen UZLĂU, PhD
Institute for Economic Forecasting - NIER, Romanian Academy and
Hyperion University, Faculty of Economic Sciences
Calea Calarașilor no. 169, district 3, Bucharest, 030615
carmen_uzlau@yahoo.com

Corina Maria ENE, PhD
Hyperion University, Faculty of Economic Sciences
Calea Calarașilor no. 169, district 3, Bucharest, 030615
corina.maria.ene@gmail.com

Abstract

The mobility of labor, defined as responsiveness and adaptation of persons or groups of persons on the challenges of the social and economic environment is therefore a social phenomenon depending on time and space. A high mobility increases opportunities for workers to find a job and employers to find persons with an adequate level of skills, thus boosting employment and economic growth. In recent years, in Romania there has been an accentuation of existing gaps, compared with the European Union countries, as regards the occupational structure of employment. In this context, the paper proposes an analysis of the evolution of labor mobility in the main sectors of the Romanian economy. Also, it was pursued the Markovian modeling of employees' mobility on the labor market and its forecast in Romania, under the impact of rapid and profound social and economic changes, and the correlation between them as well, with a view to make forecasts of the Romanian economy evolution in the short term.

Key words: employees, Markov chains, mobility, forecast

JEL classification: C19, C53, J21, J45, J61

1.Introduction

The transition to a market economy is a specific process that involves changing the property regime in favor of the private one and the competition promoting, specific regulating mechanisms of the market economy, mainly based on the law of supply and demand as well as the renewal of state intervention for the purpose of fiscal and monetary policy adjustment with the aim of fundamental economic imbalances relief.

Romania, as a member country of the European Union since 2007, is sustaining efforts to substantially reduce the still existing gap in relation to the countries of this region, for the modernization of the Romanian economy, in step with the needs of the transition to a modern informational economy, and to achieve performance criteria set by the Maastricht Treaty.

Yet faced with internal and external imbalances, Romania had to focus their efforts on: reducing the fiscal and quasi-fiscal deficit, continue the tax reform, to give up on using the exchange rate as an instrument of insuring balance, to accelerate reforms and fulfill the conditions in order that Romanian economy to receive the grade of a functional market economy. It has been pursued the promotion of coherent policies, compatible with the mechanisms of the European Union, aimed at selectively restructuring the economy, the development and modernization of physical, scientific and social infrastructure, revitalization of potentially competitive industries, building sustainable agriculture based on optimum size holdings, supporting information technology-based activities and the creation of an environment conducive to tourism development, expansion and diversification of financial services, of the tertiary sector in general.

Important roles in the development of forecasts on the evolution of macroeconomic indicators that contribute to re-launching economic growth and various models have, as well, the Markovian models. With their help, there can be analyzed and forecasted different phenomena and economic correlations between them.

After the 6^{th} decade of the last century, Markov chains and processes have experienced an explosive growth of their use in the sciences about people and their problems: demography, social mobility theory, education systems, ecology, pollution, etc. Multiple applications of these methods may be found in biology and medicine.

Given the huge area of Markov chains use, in the first part of this chapter there is presented a summary of the progress made in the world use Markovian models in various fields of activity.

In the field of the economy, the use of these methods, particularly in the Romanian economy, it had however had a lesser extent. Addressing the issue of the population growth process and of the labor market parameters dynamics or Romania's external trade by using Markov or semi-Markov chains and processes, is a substantial contribution to the development of techniques for modeling economic phenomena and a useful tool in making economic forecasts.

The work presents a Markovian model developed both for the study of labor mobility in the various sectors of the economy, as well as for its forecast.

Application of the Markovian modeling theory on economic phenomena, as well as on the economic sectors issues, on the analysis of the main macroeconomic indicators' correlation degree in developing macroeconomic forecasts can contribute to re-launching economic growth that has become a priority for macroeconomic policy, starting from its importance, firstly, in the present situation of economic upswing, of surpassing the socio-economic problems due to the current economic and financial crisis.

2. The world stage of the analysis on the development of some processes/phenomena using Markovian patterns

The concept of Markovian dependency, due to the Russian mathematician A. A. Markov, appears for the first time in an explicit form in the article *Rasprostranenie zakona bolşih cisel na velicinî, zaviseaşcie drug ot druga*, published in 1906 in Izv. Fiz. – mat.obşc. pri Kazansk. Univ., 2-ia seria 15, no. 4, p. 135-156. In a series of works which begins with the cited one, Markov studies the properties of certain dependent random variables string, which today are called, in honor of his name, the Markov chains. Markov's intention was to generalize the classical properties of independent random variable strings to strings that do not satisfy the assumption of independence. Reliance also must be considered "natural", i.e. to meet the various possible applications.

The number of books and articles devoted to Markovian dependency, since 1906 until today is unimaginable. Books or monographs written by Hostinsky, R. von Mises, M. Fréchet, S.N. Bernstein, V. I. Romanovski, W. Feller and K. L. Chung have marked milestones in the history of Markov chains.

To the development of the Markovian theory an important role had as well the founders of the Romanian School of probability theory: Octav Onicescu and Gheorghe Mihoc.

The concept of Markovian dependency in continuous time was introduced by A.N. Kolmogorov in 1931.

If from the outset, Markov focused his attention on the theoretical aspects of dependency which he entered, subsequently he was preoccupied as well by the practical applications of the new concept. Thus, since 1913, Markov has achieved within an article, the statistical analysis of the novel Eugene Onegin by Aleksandr Pushkin. He concluded that the sequence of vowels and consonants in the text of the novel can be seen as a simple homogeneous Markov chain with two postures.

Started so by Markov, the use of the dependency which bears his name in the real phenomena modeling has known, after the war, a proliferation hard to imagine: a large number of articles on Markovian modeling were written covering a vast area, being used in very many sectors.

Some of the areas in which Markov chains apply worldwide are:

a) Applications in technics: statistic control of industrial production quality (Wilson & Burgess (1971)), safety in operation of complex technical systems (Barlow and Proschan (1965), Bhat Gnedenko (1972), (1972), BeliaevSoloviev, Gondran (1975), Anderson (2001), Wei Cai & Malvin (2002));

b) Applications in the so-called exact sciences: physics (Bharucha-Reid (1960), Esa Virtamo Hyytia & j. (2001), quantum mechanics, thermodynamics (Ehrenest model with recurring Markov chains has been used to explain some irreversible phenomena in thermodynamics, namely the elucidation of a paradox that, at the beginning of the 20th century was about to frustrate the efforts of L. Boltzmann to explain thermodynamics on the basis of kinetic theory of matter), statistic physics, chemistry, astronomy and astrophysics;

c) Applications of mathematical modeling in psychology and genetics – one of the most momentous achievements of the 19th century-biology is the cell theory – the type of cross models based on a Markov chain with two absorbent states and four non-recurrent states. The fundamental mathematical model of the genetic drift was introduced by S. Wright in 1931 and identified as a finished Markov chain by G. Malécot in 1944. Also, Markovian models are used to study the genetic composition of a fix volume haploid population;

d) Pioneering articles for tanks theory were dedicated, in their great majority, to establish the conditions under which a statistical equilibrium situation comes up, i.e. studying the asymptotic behaviour of Markov chain $(Z(n))_{n\in\mathbf{N}}$, n $\to\infty$, where Z (n) is the water quantity at the moment n∈N in a finite-capacity tank;

e) Renewal models use Markov chains and are of great practical importance since they are determined by the problems posed by the failure and replacement of some components of a complex system.

f) For performance evaluation of error correction and detectors codes there are used models of the numerical channels: Markov models with finite number of possible states or renewal models.

g) Queuing theory studies mathematical models with Markov chains for various units and requests waiting to be served in a certain order.

h) Markovian modeling of economic phenomena: Kemeney & Snell (1960), generally, *the production theory* of Sackowitz & Samuel-chan (1974/1975), *the mobility of labor*

Bartholomew (1973, 1982), *financial operations* Cyert Davidson & Thompson (1961), *bank notes circulation* Baroszynschi (1972/1973), Michael Dueker (2001). Markovian models on the *dynamics of labor* were developed by Bartholomew (1973), Feichtinger & Mehlmann (1976), Mehlmann (1997), Catherine Donati-Martin and Marc Yor (2000, 2001), Paul Biemer (2001), Alexandru Voicu (2002), Maloney & Arago (2001). *Study of economic cycles or economic growth* using Markov chains was conducted by Michael Dueker and Christopher J. Neely (2000), Qinru Qiu and Massoud Pedram (2001), Guillaume Guerrero and Yuri N. Levchuk, (2001).

Therefore, it can be said that the study of economic phenomena, due to its features, an important role lies as well, with their modeling using stochastic processes and in particular with the Markovian models.

3. Markovian models for the analysis of labour mobility – theoretical presentation

One of the time-dependent social phenomena is, also, labor mobility between different sectors of the economy or within the same sector. If it is considered an appropriate time scale, you can find that part of the labor force who suffers changes from one time period to another. It is assumed that at some point, an employee would like to be employed in any of the m "sectors of the economy". The number of employees in the system is assumed to remain the same throughout the analysis period.

It is assumed that the number of employment recorded at regular intervals as the number of employees which changes work during any period is known. Also it is assumed that their distribution is also posted.

Assuming the present experience of the employees in a sector influences the choice of other sectors, Markov chains model gives an approximation to the real behavior of employees in the labor force of the economy branches. Sometimes, this phenomenon can be best approximated with the help of semi-Markov processes. If it is assumed that the change of job of an employee occurs following a Poisson model - the length of time during which any employee could be at work has a negative exponential distribution – then, the Markov chains model is satisfactory.

If $\{S_n, n = 0,1,2,...\}$ is the employees' status at a given time and n the number of observations, the space of S_n 's states is $\{0,1,2,...m\}$, m being those sectors of the economy.

Transition probability matrix can be estimated using statistical data and information on the characteristics of labor mobility in the sectors concerned.

In the analysis carried in 1955 by Blumre, there were considered 11 sectors of the economy, ranging from agriculture, construction, publications, etc. to business and Government activities. In addition, the 11^{th} component was considered unemployment.

The inclination of a particular category of labor force not to change work for a longer period determined dividing the occupied population into two groups: one that contains those individuals that do not change the work, and another, containing people who change work.

If m is considered to be sectors of the economy, with $s_i \ (i = 1,2,...,m)$ the fraction containing population who do not change the work i, then the crossing probability matrix for population changing the workplace can be written in the form:

$$\mathbf{R} = \begin{pmatrix} R_{11} & R_{12} & \dots & R_{1m} \\ . & . & \dots & . \\ . & . & \dots & . \\ R_{m1} & R_{m2} & \dots & R_{mm} \end{pmatrix} \quad (1)$$

Crossing probabilities matrix for the entire active population becomes:

$$\mathbf{P}=\begin{pmatrix} s_1+(1-s_1)R_{11} & (1-s_1)R_{12} & \dots & (1-s_1)R_{1m} \\ (1-s_2)R_{21} & s_2+(1-s_2)R_{22} & \dots & (1-s_2)R_{2m} \\ . & . & \dots & . \\ . & . & \dots & . \\ (1-s_m)R_{m1} & (1-s_m)R_{2m} & \dots & s_m+(1-s_m)R_{mm} \end{pmatrix}=S+(I-S)R \tag{2}$$

where **S** is the corresponding matrix for the segment of occupied population not changing the workplace and it is a diagonal matrix:

$$\mathbf{S}=\begin{pmatrix} s_1 & 0 & . & . & . & 0 \\ 0 & s_2 & 0 & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & 0 \\ 0 & 0 & . & . & 0 & s_m \end{pmatrix} \tag{3}$$

For the first n steps of transition probabilities, it is assumed that no change occurs in the first category of labor force.

Then,

$$\left\|P_{ij}^{(n)}\right\|=\mathbf{S}+(\mathbf{I}-\mathbf{S})\mathbf{R}^n \tag{4}$$

with $\lim_{n\to\infty} R^n=\mathbf{\Pi}'$, where matrix $\mathbf{\Pi}'$ has identical lines, each line being the vector's limit:

$$(\pi_1',\pi_2',\dots\pi_m') \tag{5}$$

for the employees category that change their workplace.

If it is assumed $\lim_{n\to\infty}\left\|P_{ij}^{(n)}\right\|=\mathbf{\Pi}$, from relations (4) and (5) we get:

$$\mathbf{\Pi}=\mathbf{S}+(\mathbf{I}-\mathbf{S})\mathbf{\Pi}'=\begin{pmatrix} s_1+(1-s_1)\pi_1' & (1-s_1)\pi_2' & \dots & (1-s_1)\pi_m' \\ (1-s_2)\pi_1' & s_2+(1-s_2)\pi_2' & \dots & (1-s_2)\pi_m' \\ . & . & \dots & . \\ . & . & \dots & . \\ (1-s_m)\pi_1' & (1-s_m)\pi_2' & \dots & s_m+(1-s_m)\pi_m' \end{pmatrix} \tag{6}$$

what indicates that the labour force in different sectors of the economy does not depend on the initial state.

If the initial distribution of employees in various sectors of the economy is known, their distribution after *n* time periods can be obtained with the help of relations (4) and (6) for $n<\infty$ as well as for $n\to\infty$.

If $\left\{p_j^{(n)}\right\}_{j=1}^{m}$ is the distribution of employees after *n* transitions, for the vector $p^{(n)}=\left(p_1^{(n)},p_2^{(n)},\dots,p_m^{(n)}\right)$ we get:

$$p^{(n)}=p^{(0)}S+p^{(0)}(I-S)R^n \tag{7}$$

and for $p^* = \lim_{n\to\infty} p^{(n)}$ we get:

$$p^* = p^{(0)}S + p^{(0)}(I - S)\Pi' \tag{8}$$

In practical problems, implementing this Markov model requires estimation of R crossing matrices' elements and of the number of employees in each category in each sector concerned. If, for a given period of time, it is not possible to determine the number of people who change or not the workplace, then it is necessary to know the overall number of persons who will retain the workplace for another period of time and the number of those who will leave. With this information there can be determined the crossing matrix. If n_i is the number of employees in the sector i at a given moment, from which $n_{ij}^{(1)}$ move to sector $j\ (j = 1,2,...,m)$, then, (i, j) element of the matrix **P** has an estimated maximum probability:

$$\left[s_i + (1 - s_i)R_{ii}\right] = \frac{n_{ii}^{(1)}}{n_i} = \hat{P}_{ii} \quad for \quad i = 1,2,...,m \tag{9}$$

and

$$\left[(1 - s_i)R_{ij}\right] = \frac{n_{ij}^{(1)}}{n_i} = \hat{P}_{ij} \quad for \quad i \neq j \tag{10}$$

If $f_i^{(k)}$ is the employees' fraction in the sector $i\ (i = 1,2,...,m)$ that stay within this sector for the next k time period, then:

$$f_i^{(k)} = \left[s_i + (1 - s_i)R_{ii}^k\right], \tag{11}$$

or

$$1 - f_i^{(k)} = \left[(1 - s_i)(1 - R_{ii}^k)\right] \tag{12}$$

Combining relations (9) and (12) we get

$$\left[\frac{R_{ii} - R_{ii}^k}{1 - R_{ii}^k}\right] = \frac{\hat{P}_{ii} - f_i^{(k)}}{1 - f_i^{(k)}} = h_{ii} \tag{13}$$

Combining relations (10) and (12) we get

$$\left[\frac{R_{ij}}{1 - R_{ii}^k}\right] = \frac{\hat{P}_{ij}}{1 - f_i^{(k)}} = h_{ij} \tag{14}$$

Relation (13) may be written also:

$$\hat{R}_{ii} = h_{ii} + (1 - h_{ii})\hat{R}_{ii}^k \tag{15}$$

which accepts a single solution within the interval $0 \le \hat{R}_{ii} < 1$ and $0 \le h_{ii} < \left(\frac{1}{k}\right)$

from relation (14) we get:

$$\hat{R}_{ij} = h_{ij}\frac{1 - \hat{R}_{ii}}{1 - h_{ii}} \tag{16}$$

When the workforce in the sector *i* is large, estimators R_{ii} and R_{ij} obtained above, are consistent. If you know the values for the parameters s_i, determined with the aid of the relation (9), then they can be rephrased alike:

$$\hat{s}_i = \frac{\hat{P}_{ii} - \hat{R}_{ii}}{1 - \hat{R}_{ii}} \qquad (17)$$

($\hat{s}_i$ are noted for the estimation of s_i)

Solving the equation $\pi' \hat{R} = \pi'$ with $\sum_{i=1}^{n} \pi' = 1$, leads us to achieving the probability vector $\pi' = (\pi'_1, \pi'_2, ...\pi'_m)$.

4. Estimation of employees' mobility in the labour market in Romania using Markov chains and its forecast

The problem of labor mobility is addressed both in theory and in practice in connection with the need for a balanced social and economic development at the regional and sectorial level, combining structural issues with the functional reasons.

The current economic and financial crisis has strongly influenced the population's degree of employment in terms of volume and structure and has led to the adaptation of labor market policies.

Upon the conditions of the restructuring acceleration and increasing job insecurity in the labor market, a large number of social problems have accumulated. Employment has become one of the tensest areas of the society.

As a result of the fiscal adjustment authorities' efforts, the number of personnel in budgetary sector in Romania has dropped steadily from the end of 2008, mainly due to the freezing of vacant posts (in effect since May 2009) and the replacement of only a post for 7 released.

During the period September-November 2010, measures implemented from July 2010 to restore the budget balance, have had further negative effects on the labor market and on the real disposable income dynamics.

The persistence of a modest recruitment activity has led to the increase in the number of people who have given up looking for a job through the National Agency for employment (ANOFM) and therefore lowering unemployment.

In this category have entered also those affected by the restructuring of the budgetary sector, and a possible additional explanation for the phenomenon recorded at the ANOFM level might be as well the duration of procedures (according to ANOFM). From September to November 2010, the number of fired employees only in the public administration, defense and social security services surpassed with almost 17% the new registered unemployed people during the same period as a result of collective dismissals (including those from the private sector).

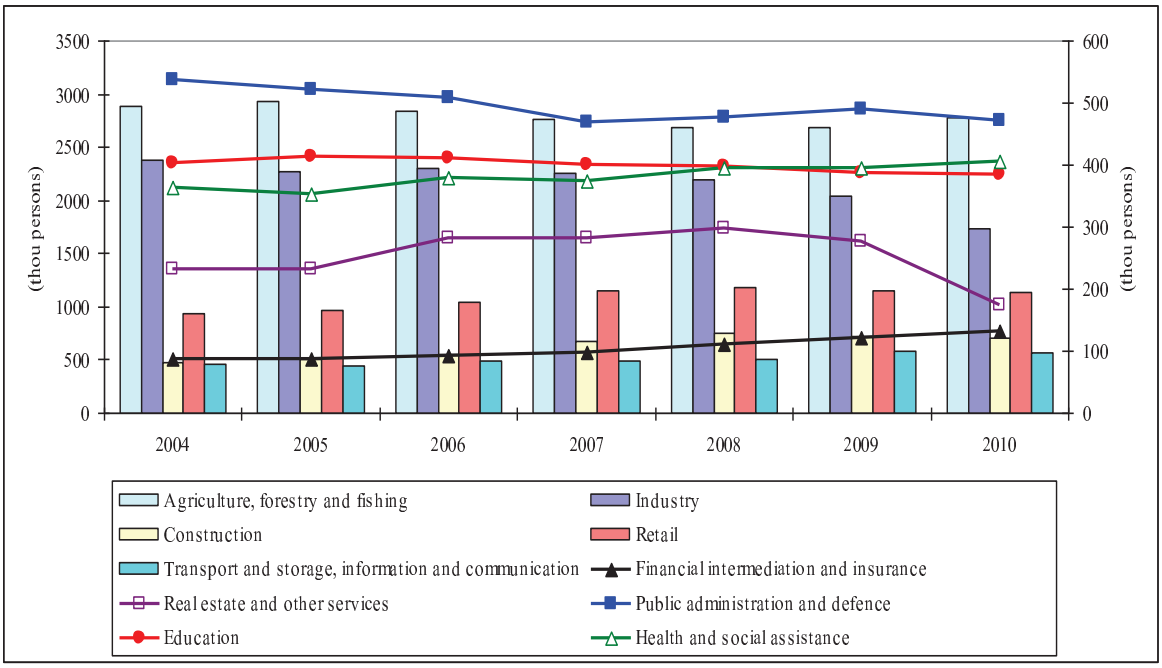
As a result, for the first time since the second quarter of 2008, the registered unemployment rate decreased on average by 0.2 percentage points in the third quarter of 2010 and by a further 0.5 percentage points during the months of October-November. The trend, however, is not found in the data on the ILO unemployment rate, which has increased by 0.3 percentage points in the third quarter of 2010, returning to the level of 7.4% in quarters IV 2009 and I 2010, which indicates that some of the unemployed people who have come out of the registers ANOFM continued to look for a job by their own means.

In the following, we are proposing an analysis of labor mobility in the various fields of economic activity with the help of Markov models.

For the proposed analysis data on employment in the Romanian economy during the period 2004-2010 have been used. Evolution of the number of employed persons in each of these branches is graphically presented in Figure 1.

Figure 1

Employment Structure, by Activity of National Economy



Source: Romanian Statistical Yearbook 2005-2011, National Institute of Statistics

For the proposed analysis there were considered 11 branches of the national economy: industry, agriculture, construction, trade, transportation, storage and communications, financial intermediation, real estate transactions and other services, public administration and defense, education, health and social assistance and other national economy activities (table 1). Status 1, 2,...11 are considered non-recurrent. There has been also introduced an additional condition, namely 0, this being regarded as being absorbent.

Table 1

Economy branch	*Status*
Agriculture	1
Industry	2
Constructions	3
Trade	4
Transportation, storage and communications	5
Financial intermediations	6

Real estate transactions and other services	7
Public administration and defense	8
Education	9
Health and social assistance	10
Other national economy activities	11

Based on the relations shown in subchapter 2, in a first stage, the vector corresponding to the number of employed persons in each branch has been determined:

$$\eta(2004) = (2893;\ 2377;\ 479;\ 943;\ 454;\ 86;\ 232;\ 538;\ 402;\ 362;\ 240)$$

$$\eta(2005) = (2939;\ 2269;\ 507;\ 968;\ 450;\ 86;\ 232;\ 520;\ 413;\ 353;\ 255)$$

$$\eta(2006) = (2840;\ 2296;\ 557;\ 1049;\ 492;\ 92;\ 281;\ 508;\ 410;\ 379;\ 263)$$

$$\eta(2007) = (27579;\ 2259;\ 679;\ 1151;\ 489;\ 97;\ 282;\ 468;\ 400;\ 375;\ 253)$$

$$\eta(2008) = (2690;\ 2199;\ 747;\ 1176;\ 509;\ 110;\ 298;\ 476;\ 397;\ 396;\ 211)$$

$$\eta(2009) = (2689;\ 2048;\ 726;\ 1157;\ 578;\ 122;\ 276;\ 490;\ 386;\ 395;\ 211)$$

$$\eta(2010) = (2761;\ 2035;\ 719;\ 1113;\ 565;\ 133;\ 268;\ 479;\ 381;\ 405;\ 201)$$

Calculations led to getting of the crossing probabilities matrix for the population changing workplace, namely:

$$\mathbf{R} = \begin{pmatrix}
0,2 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,7 \\
0,4 & 0,1 & 0,1 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,2 \\
0,2 & 0,0 & 0,3 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,4 \\
0,2 & 0,0 & 0,0 & 0,4 & 0,1 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,2 \\
0,1 & 0,0 & 0,1 & 0,1 & 0,3 & 0,1 & 0,0 & 0,0 & 0,0 & 0,0 & 0,4 \\
0,1 & 0,0 & 0,0 & 0,2 & 0,2 & 0,3 & 0,0 & 0,0 & 0,0 & 0,0 & 0,1 \\
0,0 & 0,0 & 0,0 & 0,3 & 0,1 & 0,0 & 0,3 & 0,1 & 0,1 & 0,0 & 0,4 \\
0,0 & 0,0 & 0,0 & 0,3 & 0,0 & 0,0 & 0,3 & 0,2 & 0,0 & 0,0 & 0,1 \\
0,0 & 0,0 & 0,0 & 0,1 & 0,0 & 0,0 & 0,0 & 0,0 & 0,5 & 0,0 & 0,4 \\
0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,2 & 0,3 & 0,5 \\
0,0 & 0,0 & 0,0 & 0,6 & 0,2 & 0,0 & 0,0 & 0,0 & 0,0 & 0,0 & 0,2
\end{pmatrix}$$

Crossing probabilities matrix for the entire active population becomes as relations (2):

$$\mathbf{P} = \begin{pmatrix} 0,950 & 0,000 & 0,002 & 0,003 & 0,001 & 0,000 & 0,000 & 0,001 & 0,000 & 0,000 & 0,043 \\ 0,380 & 0,274 & 0,140 & 0,005 & 0,001 & 0,001 & 0,000 & 0,001 & 0,001 & 0,000 & 0,197 \\ 0,100 & 0,010 & 0,696 & 0,010 & 0,000 & 0,001 & 0,000 & 0,000 & 0,001 & 0,000 & 0,182 \\ 0,050 & 0,005 & 0,010 & 0,880 & 0,017 & 0,001 & 0,000 & 0,001 & 0,000 & 0,000 & 0,037 \\ 0,015 & 0,000 & 0,010 & 0,020 & 0,870 & 0,020 & 0,000 & 0,000 & 0,000 & 0,000 & 0,065 \\ 0,010 & 0,000 & 0,002 & 0,030 & 0,030 & 0,910 & 0,000 & 0,000 & 0,000 & 0,000 & 0,018 \\ 0,000 & 0,000 & 0,000 & 0,010 & 0,002 & 0,000 & 0,970 & 0,002 & 0,002 & 0,000 & 0,014 \\ 0,001 & 0,000 & 0,000 & 0,020 & 0,001 & 0,001 & 0,020 & 0,950 & 0,000 & 0,000 & 0,007 \\ 0,000 & 0,000 & 0,000 & 0,003 & 0,000 & 0,000 & 0,002 & 0,001 & 0,970 & 0,000 & 0,024 \\ 0,000 & 0,000 & 0,000 & 0,000 & 0,000 & 0,000 & 0,000 & 0,000 & 0,010 & 0,970 & 0,020 \\ 0,001 & 0,000 & 0,001 & 0,100 & 0,030 & 0,004 & 0,001 & 0,001 & 0,002 & 0,003 & 0857 \end{pmatrix}$$

and the corresponding matrix for segment of occupied population not changing workplace, can be written in the form:

$$\mathbf{S} = \begin{pmatrix} 0,938 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0,213 & 0 & . & & & & & & & 0 \\ . & 0 & 0,546 & 0 & . & & & & & & . \\ . & . & 0 & 0,798 & 0 & . & & & & & . \\ . & . & . & 0 & 0,821 & 0 & & & & & . \\ & & & & 0 & 0,867 & 0 & & & & \\ & & & & & 0 & 0,960 & 0 & & & \\ & & & & & & & 0,953 & 0 & & \\ . & . & & & & & & 0 & 0,943 & 0 & . \\ . & . & & & & & & & 0 & 0,956 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0,825 \end{pmatrix}$$

Initial distribution of employment in the various economic branches is given by the components of the vector:

$\pi_0 = \{0,4047; 0,2317; 0,0399; 0,0950; 0,0356, 0,0106; 0,0076; 0,0164; 0,0485; 0,0405; 0,0691\}$

and its distribution in the following years may be determined with the help of relations (10)-(17).

For the proposed analysis, we have got:

$\pi_1 = \{0,3857; 0,2275; 0,0546; 0,1014; 0,0408, 0,0121; 0,0080; 0,0174; 0,0489; 0,0414; 0,0621\}$

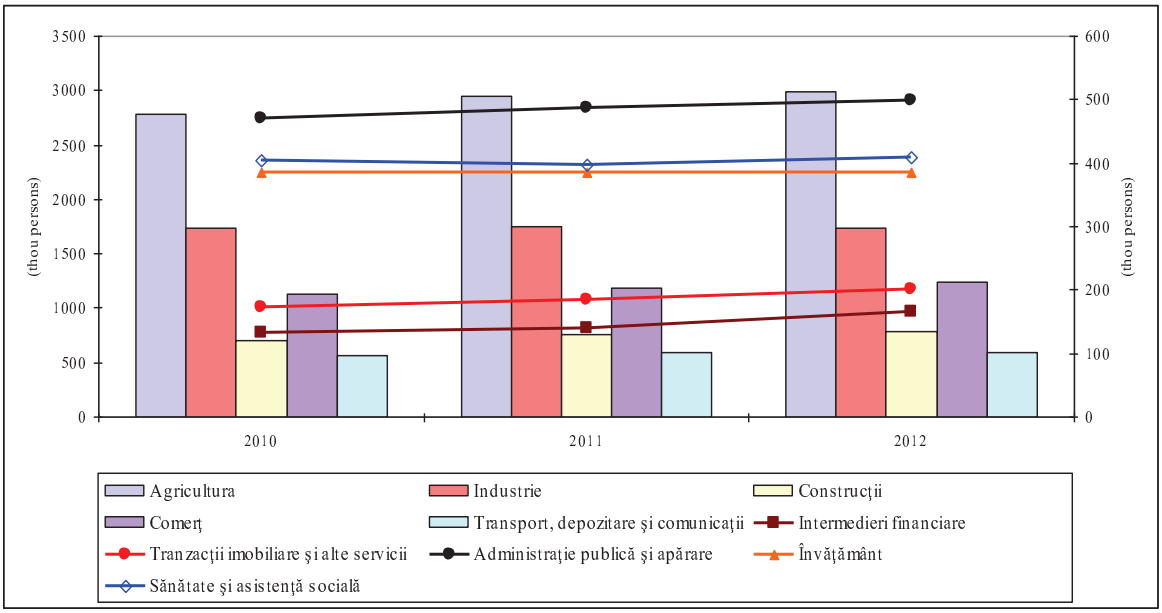
$\pi_2 = \{0,3682; 0,2257; 0,0656; 0,1087; 0,0464, 0,0135; 0,0082; 0,0176; 0,0498; 0,0416; 0,0544\}$

$\pi_3 = \{0,3520; 0,2238; 0,0727; 0,1162; 0,0522, 0,0148; 0,0091; 0,0180; 0,0521; 0,0433; 0,0457\}$

With the help of relations such obtained, labor mobility may be predicted. Thus, for the analysed sectors, the results shown in Figure 2 have been obtained.

Figure 2

Forecast of Employment Structure, by Activity of National Economy



Source: historical data: Romanian Statistics Yearbook 2010, forecast: author's calculations

Evolution of employment will be influenced by several factors. On the one hand there is the foreign investments flow that will generate new jobs. Small and medium-sized enterprises expect to have also a positive contribution to employment growth. On the other hand, the continuation of the process out of the current economic and financial crisis will induce pressure on employment, resulting in new layoffs in some sectors of activity. Despite a relatively high economic growth, labor market remains strained, mainly because of age and profession structure of unemployed persons, which is not identical with the demands of the economy.

Increasing the employment will be achieved by moving the focus on social protection of the unemployed policies from passive to active measures and the promotion of measures to prevent unemployment, especially among young people and persons exposed to the risk of becoming long-term unemployed.

Implementation of this concept and mentality of continuous training or education, without social discrimination, will respond to the needs of rapidly adapting to structural changes of technology and economy, in order to face a large professional mobility in the foreseeable future.

5. Conclusions

Overcoming the difficult moments that Romania is currently crossing largely depends on developments in the European and international economic situation. Significantly, however, the resumption of a healthy growth will be determined in the case of Romania by the consistency of implementing the prescribed landfill and stabilization measures stipulated by the agreements concluded with the European Union, the International Monetary Fund and the World Bank, convergence programs with a view to the adoption of a single European currency and the use of intelligent benefits that membership of the EU offers.

In the current situation, when the resumption of economic growth is tried, it is natural that the decision makers to use various methods and techniques of estimation which may allow them to study the evolution of macroeconomic and the same time to provide scientific support for economic phenomena forecast. One of the important elements of the macroeconomic analysis is also the study on the mobility of the labor force in the national economy.

Markov model used to study the mobility of labor in various sectors of the economy, has enabled the analysis of this phenomenon in the period 2004-2010 in 11 of the sectors of the economy. With the help of elaborated patterns there was made and forecasted labor mobility in the short term.

The results presented in this paper in the form of graphics, emphasies the tendencies of change in the number of employed persons in each of the sectors concerned. Evolution of employment will be impacted by several factors. On the one hand, there is the foreign investment flow that will generate new jobs. Small and medium-sized enterprises expect to have also a positive contribution to employment growth. On the other hand, the continuation of the process of restructuring as a result of the current financial and economic crisis consequences will induce pressure on employment, generating new layoffs. Despite an up economic growth, job market remains strained, mainly because of age and profession structure of unemployed persons, which is not identical with the demands of the economy.

Increase employment in the conditions of accelerated continuing of the crisis exit processes, will be achieved by moving the focus on social protection of the unemployed policies from passive to active measures and the promotion of measures against unemployment, especially among young people and of persons exposed to the risk of becoming long-term unemployed.

Implementation of this concept and mentality of continuous training or education, without social discrimination, will respond to the needs of rapidly adapting to structural changes of technology and economy, in order to face a large professional mobility in the foreseeable future.

6. Selective bibliography

1 Alvin, C., (1998), *Multivariante Statistical Interface and Application*, Ed. A. Wiley Interscience Publication John Wiley&Sons. Inc.;

2 Bohdana Ratitch and Doina Precup, (2001), *Characterizing Markov Decision Processes*", McGill University, Montreal, Canada;

3 Creţu A., Stanef R., *Operaţionalizarea strategiei de ocupare a forţei de muncă în România – obiectiv al integrării în Uniunea Europeană*, Economie teoretică şi aplicată, pp 89-94,

4 D.J. White, (1993), *Markov Decision Processes*, Editura Willey John W. &Sons;

5 David J. Batholomew, (1982), *Stocastic models for Social Processes*, Editura John Willy&Sons;

6 E. Ashley Steel, Peter Guttorp, James J. Anderson, David C. Caccia, (2002), *A Simple Markov Chain,* National Research Center for Statistics and the Environment, University of Washington;

7 Felix Klock and Jeremy Nimmer, (2001), *Markov Models,* ESP High School Studies Program Lecture 10, M-20A: Square Peg Solutions August;

8 Gujarati, N., (1995), *Basic Econometric*, Ed. The McGraw-Hill Int. Editionc;

9 Hans-Martin Krolzig, (1998), *Econometric Modelling of Markov-Switching Vector*

Autoregressions using MSVAR for Ox, Institute of Economics and Statistics and Nuffield College, Oxford;

10 Hans-Martin Krolzig, (2000), *Markov Processes - Predicting Markov-Switching Vector Autoregressive Processes*, 4452 Mathematical Modeling Lecture 16, Department of Economics, and Nuffield College, Oxford, April;

11 He H., Liu Z, (2008), *Investment-specific technological change, skill accumulation, and wage inequality*, Review of Economic Dynamics;

12 Jonston, J., *Econometric Methods*, (1997), Ed. The McGraw-Hill Companies, Inc.;

13 Krolzing. H.M., (2000), *Markov Process*, 4452 Mathematical Modeling Lecture 16, Department of Economics and Nuffield College, Oxford;

14 Marius Iosifescu, S. Grigorescu, Gh. Oprişan, Gh. Popescu, (1984), *Elemente de modelare stohastică*, Editura Tehnică, Bucureşti;

15 Michael Rosenblum, (2001), *Mobility Modeling with a Mixed Ornstein-Uhlenbeck Process*;

16 Mihoc, Gheorghe, ş.a., (1982), *Modele de analiză statistică*, Editura Ştiinţifică şi Enciclopedică, Bucureşti;

17 Nicolae M., Albu L., Pană C., *Models of people mobility and labor force* - volume "Work force migration and durable development of Romania. Theoretic-methodological approaches. Indicators systems and models for analyze, Ed. Expert, Bucharest, 2005 ;

18 Onicescu, Octav, (1977), *Probabilităţi şi procese aleatoare*, Editura Ştiinţifică şi Enciclopedică, Bucureşti;

19 Onicescu, Octav, M. C. Botez, *Incertitudine şi modelare economică*, Editura Ştiinţifică şi Enciclopedică, Bucureşti, 1985;

20 Paul P. Biemer & John M. Bushery, (2001), „*Estimating the Error in Labor Force Data Using Markov Latent Class Analysis",* U.S. Census Bureau, Washington;

51 Preoteasa A. M**.,** *Fenomenul ocupării în România şi dezvoltarea durabilă,* Calitatea Vieţii, XIX, nr. 1–2, 2008, p. 53–69

22 Press, J., (1972), *Applied Multivarite Analysis*, Ed. Hott, Rinecart and Winston, Inc.;

23 Qinru Qiu and Massoud Pedram, (2002), „*Dynamic Power Management Based on Continuous-Time Markov Decision Processes",* University of Southern California, Los Angeles, California, USA;

24 Virtamo J., (2000), *Stochastic Processes*, 38.143 Queueing Theory/Stochastic processes;

25 Warren Gilchrist, "*Statistical Forecasting* " Editura John Willy&Sons, 1976;

*** Anuarul Statistic al României 2002-2011, Institutul Naţional de Statistică, Bucureşti;

*** *Employment in Europe 2009,* European Commission, Directorate-General for Employment, Social Affairs and Equal Opportunities Unit D.1, Manuscript completed in October 2009, www.

*** *Labour market statistics*, European Union, 2011, www. epp.eurostat.ec.europa.eu;