THE STATISTICAL MODELING OF THE EVOLUTION OF CIVIL EMPLOYMENT, BY ACTIVITY OF THE ROMANIAN ECONOMY USING THE MARKOV CHAIN METHOD

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Abstract:
In this paper we statistically model the evolution of civil employment, by activity of the Romanian economy. For this, we start from the actual data provided by National Institute of Statistics for the period 1997-2007 and using Markov chain will make a forecast of the evolution of employees by area of activity for the next three years. Also, in the second section we describe in large the Markov chain method and we will apply to this specific case.

Key words: *Markov chain method, forecast, share, the vector of initial state and the transition probability matrix*

JEL classification: *C44*

1. Introduction

In this paper we want to model the evolution of civil employment, by activity of the Romanian economy, in order to do that we will use the Markov chain method. The foundations of this method were made by the Russian mathematician A. Markov, being interpreted as a method of forecasting structural.

The use of the Markov chain method to forecast the structure of economic processes is based on the assumption that the evolution in time of the process studied depends on the probabilities of its previous structure, and the process itself has a dynamic character.

We will apply this method to make a forecast of the evolution of civil employment, by activity of the Romanian economy because it has many practical applications in the processes of structure at micro and macroeconomic level.

In this paper, the economic data used in modeling are taken from the National Institute of Statistics, Yearbook 2008, from the chapter 3 - Labor market.

According to CAEN the national economic activities are classified as follows: agriculture, hunting and forestry, fishery and fish farming, industry, construction, trade, hotels and restaurants, transport, storage and communications, financial intermediations, real estate and other services, public administration and defense, education, health and social assistance and other activities of the national economy.

2. The Markov chain method and his application

In order to achieve the forecast of the evolution of civil employment by activity of the Romanian economy, we will describe the Markov chain method combining the theory with the practice. Thus, a Markov chain is define by the vector of initial state and the transition probability matrix. The vector of initial state corresponds to the structure of the studied process for the last year, when the data are known (i.e. the data are real). The elements of the transition probability matrix are estimated in practice with the relative frequency components of the studied process (which are expressed by empirical data).

First, starting from the real values of the civil employment, by activity of the Romanian economy during 1997–2007, we compute ***the relative frequencies*** of this process. For that we divide the number of economically active persons in a category in one year to the total number of economically active persons in question. The results are given in table 2.1.

Table 2.1.

Civil employment share, by activity of national economy at level of cane section (end of year) thou persons

Activity (CAEN Rev.1 sections)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Agriculture, hunting and forestry (A)	37.50	38.00	41.16	41.37	40.85	36.15	34.72	31.97	31.87	29.68	28.21
Fishery and fish farming (B)	0.07	0.07	0.04	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.03
Industry (C)	27.15	26.29	24.39	23.22	23.55	25.48	24.79	24.91	23.52	23.25	22.44
Construction (D)	4.87	4.44	4.01	4.09	3.97	4.39	4.77	5.09	5.52	6.06	6.81
Trade (E)	8.89	9.47	8.98	8.99	9.39	10.27	10.91	11.39	12.37	13.20	13.75
Hotels and restaurants (F)	1.44	1.11	1.19	1.08	0.92	1.14	1.26	1.61	1.59	1.58	1.79
Transport, storage and communications (G)	5.60	5.23	4.81	4.86	4.68	4.81	4.84	4.90	4.98	5.35	5.48
Financial intermediations (H)	0.81	0.86	0.82	0.86	0.79	0.83	0.87	1.00	1.07	1.12	1.25
Real estate and other services (I)	2.21	2.76	2.83	3.14	3.29	3.79	4.27	4.65	4.60	5.20	5.57
Public administration and defense (J)	1.44	1.52	1.67	1.70	1.67	1.78	1.87	1.93	2.06	2.16	2.40
Education (K)	4.72	4.83	5.10	4.88	4.93	4.98	5.06	5.22	5.13	5.03	4.92
Health and social assistance (L)	3.49	3.60	3.29	3.95	4.05	4.30	4.32	4.45	4.41	4.59	4.52
Other activities of the national economy (M)	1.82	1.82	1.71	1.80	1.85	2.03	2.28	2.83	2.84	2.73	2.84
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Then, we compute ***the structural deviations*** for each pair of consecutive years since 1997 to 2007 (see table 2.2). We will illustrate the computation of the structural deviations for the years 1997– 1998 in table 2.2. Each negative deviation, recorded by a particular item will be distributed to all elements which have recorded positive deviations, proportional to the share of positive deviations when we will determine the partial transition matrix.

Table 2.2.

Structural deviations for each pair of consecutive years

	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	Total
1997	3.50	0.07	27.15	4.87	8.89	1.44	5.60	0.81	2.21	1.44	4.72	3.49	1.82	100
1998	38.00	0.07	26.29	4.44	9.47	1.11	5.23	0.86	2.76	1.52	4.83	3.60	1.82	100
Deviations	0.50	0.00	**-0.86**	**-0.43**	0.59	**-0.33**	**-0.37**	0.05	0.55	0.08	0.11	0.11	0.00	0
Positive Deviations	0.50	0.00	0.00	0.00	0.59	0.00	0.00	0.05	0.55	0.08	0.11	0.11	0.00	1.99
Share	**0.25**	**0**	**0**	**0**	**0.295**	**0**	**0**	**0.027**	**0.278**	**0.04**	**0.057**	**0.053**	**0**	**1.00**

We shall do the same for the other periods.

Next, we perform a table with an equal number of rows and columns; the number of rows is given by the number of economic activities, in our case 13 rows. This matrix represents ***the partial transition matrix***. For each pair of two consecutive years will have a partial matrix of transition. Further on, we compute the transition matrix for the first two years. Thus, on the main diagonal of the partial transition matrix we write the minimum share for each economic activity in part. If in the table of the structural deviation for the first two years, we obtain a zero share, then in the partial transition matrix we put zero on the entire column. If in the table of the structural deviation for the first two years, we obtain a nonnegative share, then in the partial transition matrix we will compute the new values based on the old one multiply it with that share. The results are given in table 2.3.

Table 2.3.

The partial transition matrix for the years 1997–1998

	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
(A)	**37.50**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(B)	0.00	**0.07**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(C)	0.22	0.00	**26.29**	0.00	0.25	0.00	0.00	0.02	0.24	0.03	0.05	0.05	0.00
(D)	0.11	0.00	0.00	**4.44**	0.13	0.00	0.00	0.01	0.12	0.02	0.02	0.02	0.00
(E)	0.00	0.00	0.00	0.00	**8.89**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(F)	0.08	0.00	0.00	0.00	0.10	**1.11**	0.00	0.01	0.09	0.01	0.00	0.02	0.00
(G)	0.09	0.00	0.00	0.00	0.11	0.00	**5.23**	0.01	0.10	0.01	0.02	0.02	0.00
(H)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.81**	0.00	0.00	0.00	0.00	0.00
(I)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.21**	0.00	0.00	0.00	0.00
(J)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.44**	0.00	0.00	0.00
(K)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**4.72**	0.00	0.00
(L)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**3.49**	0.00
(M)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.82**

After we compute all the matrices of transition from one year to another, we add them and we obtain ***the total transition matrix*** given in table 2.4.

Table 2.4.

Total transition matrix

	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	Total
(A)	350.14	0.00	2.20	1.91	3.05	0.77	0.60	0.31	1.98	0.46	0.29	0.59	1.00	363.29
(B)	0.03	0.46	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
(C)	1.99	0.02	239.47	0.83	1.54	0.15	0.19	0.17	0.86	0.36	0.21	0.59	0.19	246.56
(D)	0.47	0.00	0.04	46.23	0.17	0.01	0.00	0.01	0.14	0.03	0.06	0.03	0.01	47.20
(E)	0.42	0.00	0.00	0.00	103.86	0.01	0.00	0.00	0.01	0.02	0.03	0.00	0.00	104.35
(F)	0.10	0.00	0.05	0.01	0.17	12.52	0.00	0.01	0.14	0.02	0.01	0.08	0.01	13.13
(G)	0.45	0.00	0.05	0.00	0.17	0.01	49.11	0.01	0.13	0.03	0.06	0.04	0.01	50.06
(H)	0.04	0.00	0.02	0.00	0.02	0.00	0.00	8.92	0.01	0.00	0.01	0.01	0.00	9.03
(I)	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00	36.69	0.00	0.00	0.00	0.00	36.74
(J)	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	17.77	0.00	0.00	0.00	17.81
(K)	0.03	0.00	0.00	0.09	0.11	0.01	0.03	0.02	0.08	0.03	49.35	0.13	0.02	49.90
(L)	0.26	0.00	0.00	0.03	0.04	0.01	0.01	0.01	0.02	0.02	0.02	40.03	0.00	40.46
(M)	0.09	0.00	0.00	0.02	0.03	0.00	0.02	0.00	0.03	0.01	0.01	0.01	21.47	21.68

Next, we determine the transition probability matrix, which is obtained by dividing the elements of each line of the total transition matrix to its total value. The results are given in table 2.5.

Table 2.5.

The Matrix of transition probabilities

	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	Total
(A)	96.38	0.00	0.61	0.52	0.84	0.21	0.16	0.09	0.55	0.13	0.08	0.16	0.27	100
(B)	5.34	89.06	0.67	0.75	1.35	0.33	0.13	0.13	0.80	0.49	0.54	0.20	0.21	100
(C)	0.81	0.01	97.13	0.34	0.62	0.06	0.08	0.07	0.35	0.15	0.08	0.24	0.08	100
(D)	0.99	0.00	0.08	97.94	0.36	0.02	0.00	0.02	0.31	0.07	0.13	0.07	0.01	100
(E)	0.40	0.00	0.00	0.00	99.52	0.01	0.00	0.00	0.01	0.02	0.03	0.00	0.00	100
(F)	0.74	0.01	0.36	0.10	1.31	95.37	0.04	0.10	1.04	0.13	0.08	0.61	0.10	100
(G)	0.90	0.00	0.11	0.00	0.34	0.02	98.09	0.02	0.27	0.06	0.11	0.07	0.02	100
(H)	0.40	0.00	0.22	0.00	0.26	0.01	0.00	98.82	0.11	0.02	0.07	0.07	0.03	100
(I)	0.00	0.00	0.00	0.03	0.08	0.00	0.01	0.01	99.87	0.01	0.00	0.00	0.00	100
(J)	0.00	0.00	0.06	0.00	0.07	0.00	0.00	0.00	0.03	99.81	0.01	0.02	0.01	100
(K)	0.06	0.01	0.00	0.18	0.22	0.02	0.06	0.03	0.17	0.05	98.90	0.27	0.04	100
(L)	0.64	0.00	0.00	0.09	0.11	0.03	0.02	0.01	0.04	0.06	0.05	98.94	0.01	100
(M)	0.41	0.00	0.00	0.10	0.16	0.01	0.07	0.01	0.12	0.04	0.03	0.03	99.01	100

To make a forecast of the economic phenomenon studied we need to compute the transposed of the transition probabilities matrix, given in table 2.6.

Table 2.6.

The transposed matrix of the transition probabilities

	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
(A)	0.96	0.05	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00
(B)	0.00	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(C)	0.01	0.01	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(D)	0.01	0.01	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(E)	0.01	0.01	0.01	0.00	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(F)	0.00	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(G)	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.00
(H)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00
(I)	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	1.00	0.00	0.00	0.00	0.00
(J)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
(K)	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00
(L)	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.00
(M)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99

Finally, we can make a forecast of the economic phenomenon studied, by activities of the Romanian economy for the next three years using the formula

$$S_k = \left(P^t\right)^k \cdot S_n ,$$

where:

- S_k represent the structure of elements studied process in the "k" year of forecasting (in our case, the corresponding areas of economic activity for Romania in 2008, 2009 and 2010 respectively);
- $\left(P^t\right)^k$ represent the transpose matrix of the transition probabilities rise to power "k" (in our case, for the year 2008, k is the first year of forecast, i.e. $k = 1$);
- n represent the last year for which we have real data (in our case 2007).

Thus, applying the above formula we obtain the data from table 2.7.

Table 2.7.

The results of forecast for the evolution of civil employment, by activities of Romanian economy for the next three years

The forecast	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
2007	28.21	0.03	22.44	6.81	13.75	1.79	5.48	1.25	5.57	2.40	4.92	4.52	2.84
2008	27.61	0.03	21.99	6.91	14.16	1.78	5.44	1.28	5.87	2.48	4.93	4.60	2.92
2009	27.03	0.03	21.54	7.01	14.56	1.78	5.41	1.31	6.16	2.56	4.94	4.69	2.99
2010	25.92	0.03	20.69	7.18	15.33	1.77	5.33	1.37	6.72	2.73	4.96	4.85	3.12

Graph representing the obtained data we notice that some areas of economic activity have lost weight over time (as agriculture, hunting and forestry, or industry), while others started to evolve (as trade or construction), while others remain almost constant (as education). Thus we get an overview of the evolution of the economic phenomenon studied for the next periods.

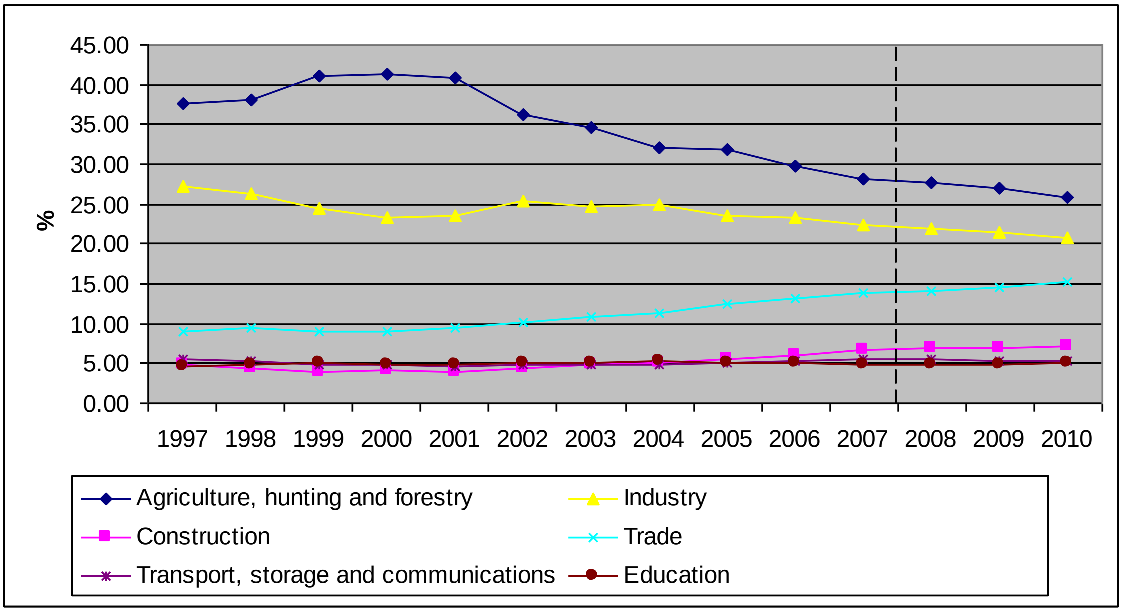

Figure 2.1. The evolution of some economic activities in Romania between 1997 and 2010

3. Conclusions

We can make a forecast of the civil population evolution of civil employment, by activity of the Romanian economy using the Markov chain method. Although using this method requires a large amount of computations, this difficulty can be overcome by the use of electronic computing. Also, this method can not identify other external factors that could influence the forecast for the next two or three years (in our case can not provide the Romania's economic instability during 2009-2010).

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