Theoretical and Empirical Researches in Urban Management
Volume 6 Issue 4 / November 2011

USING MARKOV CHAIN ANALYSIS TO ASSESS THE CONVERGENCE TRENDS IN THE EMPLOYED POPULATION IN ROMANIAN URBAN AREAS

Daniela HÎNCU
Academy of Economic Studies, Piata Romana 6, Bucharest, Romania
Daniela.hincu@man.ase.ro

Abstract
The paper presents an application of a short time forecasting methods used to make forecast on the population employed in various economic activities. The rates of employment, along with some demographic features of the local inhabitants are of major interest for the highly responsible decision makers and urban planners and for the business environment, as well for the local institutions in delivering different public services. The Markov chain analysis is used to allow pointing out the divergent dynamics of the proportion the employed person in various territorial areas vs. the national trend, as revealed by the numerical application of the Markov method. The raw data were imported from the Eurostat database (updated autumn 2011), the folder concerning the Urban audit – derived indicators for 14 Romanian main cities (including Bucharest) and Regional statistics's section – Regional employment - Employment by economic activity, at NUTS levels 1 and 2 (1000 persons).
Keywords: Markov chain, population, urban areas

1. INTRODUCTION

More and more lately the sustainability issue keeps alive the interest of the decision makers at central and local institution having in view the commandment of designing policy action plans to foster the sustainable development. The last edition of the Human Development Report 2011 named "Sustainability and Equity: A Better Future for All" argues that the urgent global challenges of sustainability and equity must be addressed in a collaborative manner all around the globe, at any kind of regional level. It identifies examples of policies meant to promote a mutually reinforcing progress towards the sustainable and intelligent economic gowth. For this aim, actions are needed to foster the human development progress for the world's poor majority, for the lean benefit of future generations as well as for those living today.

2. LITERATURE REVIEW

In the literature related to the context of city living, quality of life represents a key issue in the evaluation of a city's living environment (Lim, 1999). Knowledge about all kinds of domains of the urban life, expresses as indicators is constantly growing is usage and credibility. There are different kinds of indicators for different purposes: management indicators (on input, process, performance, output, etc.), policy indicators (outcome, impact, distance to target, etc.) and state indicators (objective, subjective, etc.) (van Assche, 2009). Their role as performance indicators serve as a decision making instrument as a management tool and are used to improve the efficiency of the activities. Policy indicators rather focus on policy impact and the effectiveness of a policy. State indicators assess the actual state of the external society. Van Assche et. all (2009), attempting to develop the liveability indicators for cities, based on sustainability concept, in the Flemish region, describe the Flemish city monitor 2006 containing about 200 state indicators that describe evolutions of the urban actors and factors in shaping the image of the urban society in the Flemish Region. The city monitor measures the outcome (actions and services of the various actors) of actions of many actors in the urban context.

A book written by Hersh (2006)aimed at providing advanced technical details of several of the available mathematical and computing methods used for the sustainable development, thus closing an visible gap between the theoretical conceptual models and their illustrating use through case studies and examples (Hersh, 2006).

In general terms, all kinds of indicators must fulfill a number of requirements: they must be accessible (data must be easy to get over an adequate period of time), understandable (provide a strong statement regarding the issue addressed), easy to be shared (public administrators and citizens must get the message at a glance), reliable (not only scientifically, but especially in the common sense: they don't have to generate misunderstandings) and finally they must be owned by the community (they are sensitive political tools, they need strong consensus). As a consequence of the above mentioned requirements all kinds of indicators, including those aiming at improving the quality of the built environment, must be defined and agreed at local level (Subsidiarity) in a participative process (Good Urban Governance) and exploiting the opportunities given by new telecommunication technologies (Information and Knowledge Economy) in order to increase impact and minimise costs (Borghi, 2010).

Theoretical and Empirical Researches in Urban Management
Volume 6 Issue 4 / November 2011

3. DATA SOURCES FOR APPLICATION

Data on urbanization, traffic and congestion, and air pollution are from the United Nations Population Division, World Health Organization, International Road Federation, World Resources Institute, and other sources.

Improving the attractiveness of regions and cities to enter in the attention zone of sustainable development supported by reasonable funds is one of the explicitly stated priorities tin the Europe 2010 Strategy and in the European Union's strategic guidelines for fostering cohesion policy till 2013. The EU organisations take a leading position in the sustainable development of various regions and cities, encouraging good practices, providing incentives and technically supporting local authorities.

TABLE 1 - THE LIST OF DOMAINS COVERED BY THE URBAN AUDIT EUROSTAT DATASET

Demography	1.1 Population
	1.2 Nationality
	1.3 Household structure
Social aspects	2.1 Housing
	2.2 Health
	2.3 Crime
Economic aspects	3.1 Labour market
	3.2 Economic activity
	3.3 Income disparities / Poverty
Civic involvement	4.1 Civic involvement
	4.2 Local administration
Training and training provision	5.1 Education and training provision
	5.2 Educational qualifications
Environment	6.1 Climate / Geography
	6.2 Air quality and noise
	6.3 Water
	6.4 Waste management
	6.5 Land use
Travel and transport	7.1 Travel patterns
Information Society	8.1 Users and infrastructure
	8.2 Local e-government
	8.3 ICT sector
Culture and recreation	9.1 Culture and recreation
	9.2 Tourism

Many sets of indicators have already been produced to monitor and enhance the quality of the urban environment, also at European level (e.g. Urban Audit and European Common Indicators), but none of them has succeeded in taking adequately into account the physical and morphological dimension of cities (Borghi, 2010). Quality of life is seen as a crucial aspect in attracting and retaining a skilled labour force, businesses, students, tourists and, most of all, residents in a city. In this prospective, for assessing the current situation of the urban management and policy making, a prerequisite for any

improvement, development and future monitoring in the various type of city areas, the European Union web site provide a vast database related to urban audit information.

The raw data were imported from the Eurostat database (updated autumn 2011)[1], the folder concerning the Urban audit – derived indicators for 14 Romanian main cities (including Bucharest) and Regional statistics's section – Regional employment - Employment by economic activity, at NUTS levels 1 and 2 (1000 persons).

The "Urban Audit" data collection[2] provides large volume of information and allows comparable measurements on the different aspects of the quality of urban life in European cities (Table 2).

TABLE 2 - THE OPTIONS OF STATISTICAL DATA IN EUROSTAT'S URBAN AUDIT

Main tables	Database
Demographic indicators: Total resident population; Households with children aged 0-17 Social indicators: Average living area in square metres per person; Mortality rate for <65 from heart diseases and respiratory illness; Number of car thefts per 1 000 population Training and Education indicators - Students in higher education (ISCED 97 levels 5-6) per 1 000 population Economic indicators: Activity rate, Unemployment rate Travel and transport indicators: Number of registered cars per 1000 population; Environment indicators: Collected solid waste per capita per year Cultural indicators: Total annual tourist overnight stays in registered accommodation per year	Key indicators for core cities Derived indicators for core city Derived indicators for larger urban zones Derived indicators for sub-city districts Reduced set of derived indicators for 570 cities Data collected for core city Data collected for larger urban zones Reduced set of data collected for 570 cities Perception survey results

4. APPLYING THE MARKOV CHAIN METHOD FOR POPULATION FORECASTING

Markov-switching model takes the regime-switch as an endogenous variable and a random process, which enable it to describe all the remarkable structural change in one united model and help to forecast.

The core principle of Markov's chain method (Lazăr & Lazăr, 2009) lies in forecasting a phenomenon taking into consideration the vector of the initial state (St) and the matrix of the transition probabilities from state t to state t+1. Applying this method implies going through the several stages, starting with computing the partial transition matrices to making short time forecasting based on the final transition matrix.

[1] http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/city_urban
[2] http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/city_urban/urban_audit_data_collections

Theoretical and Empirical Researches in Urban Management
Volume 6 Issue 4 / November 2011

A matrix of transition probabilities (TM) describes the dynamics from state t to state t+1; to use the method for forecasting structural evolution of a system among various states, the matrix is determined in several steps, beginning with computations of the delta values $\Delta_{t/t-1}$. The calculation of differences of first rank in the state vector suppose the equation:

$$\Delta_{t/t-1} = S_t - S_{t-1} \qquad \text{(Eq. 1)}$$

where S_t and S_{t-1} are state vectors in which the elements correspond to the weights of the components of the phenomenon, at moments t and t-1. Then, it continues with determining the partial transition matrixes PTMt/t-1 for each pair of successive time intervals, as a squared matrix with the n dimension (corresponding to the number of states). In the PTM matrix, the elements on the main diagonal are computed as the minimum value between the numbers of a certain state corresponding to the different moment of time:

$$ptm_{t/t-1}^{\ ii} = \min(s^i{}_t, \quad s^i{}_{t-1}) \qquad \text{(Eq. 2)}$$

The differences found previously are now distributed in the matrix and represent the percentage of increase and decrease of the analyzed indicator's structure; so, the rest of the non-zero elements lie at the intersection of those rows and columns that have a non-zero difference $\Delta_{t/t-1}$ and their numeric value is determined by the equation:

$$pt_{t/t-1}^{\ ij} = \left| \frac{\Delta^{poz}{}_{t/t-1} \cdot \Delta^{neg}{}_{t/t-1}}{\sum_{i=1}^{m} \Delta^{poz}_{t/t-1}} \right| \qquad \text{(Eq. 3)}$$

where: $\Delta^{poz}_{t/t-1}$ is the positive difference (on a column); $\Delta^{neg}_{t/t-1}$ is a negative difference (placed on the row) and $\sum_i \Delta^{poz}_{t/t-1}$ is the total sum of the positive values of the difference vector.

The final transition matrix (TM) is given by summing up all the partial transition matrixes PTMt/t-1, with t=2,3,…, obtaining the non-zero elements:

$$tt^{ij} = \sum_{t=2} p^{ij}_{t/t-1} \ \text{(i,j=1,…n)} \qquad \text{(Eq. 4)}$$

and then, by making the computations as follows:

$$p_{ij} = \frac{tt^{ij}}{\sum_{j=2} tt^{ij}} \quad \text{(Eq. 5)}$$

where pij expresses the transition probabilities from state i to state j.

TABLE 3 - REAL DATA FOR ROMANIA - EMPLOYMENT BY ECONOMIC ACTIVITY, AT NUTS LEVELS 1 AND 2 (1000 PERSONS) (NACE REV.2)

Romania	2008	2009	2010
Agriculture, forestry and fishing	2689.3	2689.1	2779.9
Industry (except construction)	2211.9	2048.6	1943.7
Construction	748.9	725.9	704.8
Wholesale and retail trade, transport, accommodation and food service activities	1774.7	1776.3	1757.5
Information and communication	119	123.3	125.9
Financial and insurance activities	110.4	122.1	132
Real estate activities	15.2	15.5	19.2
Professional, scientific and technical activities; administrative and support service activities	284.4	298	312.9
Public administration, defense, education, human health and social work activities	1245.4	1270.7	1259.3
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	169.7	173.9	204.1
Total	9368.9	9243.4	9239.3

The next table represents the proportions of employment on some important types of economic activities (Table 4). The objective is to infer the behavior of switching options to be employed among various type of activity, the reasoning that will be based on Markov chain analysis.

TABLE 4 - PROPORTION OF EMPLOYMENT ON VARIOUS TYPE OF ACTIVITY (PERCENTAGE FROM THE TOTAL) - ROMANIA

Romania	2008	2009	2010
Agriculture, forestry and fishing	28.70%	29.09%	30.09%
Industry (except construction)	23.61%	22.16%	21.04%
Construction	7.99%	7.85%	7.63%
Wholesale and retail trade, transport, accommodation and food service activities	18.94%	19.22%	19.02%
Information and communication	1.27%	1.33%	1.36%
Financial and insurance activities	1.18%	1.32%	1.43%
Real estate activities	0.16%	0.17%	0.21%
Professional, scientific and technical activities; administrative and support service activities	3.04%	3.22%	3.39%
Public administration, defense, education, human health and social work activities	13.29%	13.75%	13.63%
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	1.81%	1.88%	2.21%

TABLE 5 - PROPORTION OF EMPLOYMENT ON VARIOUS TYPE OF ACTIVITY (PERCENTAGE FROM THE TOTAL) – BUCHAREST-ILFOV

Romania	2008	2009	2010
Agriculture, forestry and fishing	1,40%	1,50%	1,01%
Industry (except construction)	15,69%	15,38%	14,10%
Construction	11,06%	9,80%	9,48%
Wholesale and retail trade, transport, accommodation and food service activities	33,26%	32,28%	31,65%
Information and communication	4,47%	4,90%	5,18%
Financial and insurance activities	2,84%	3,23%	4,15%
Real estate activities	0,52%	0,59%	0,72%
Professional, scientific and technical activities; administrative and support service activities	8,43%	8,29%	8,68%
Public administration, defense, education, human health and social work activities	19,69%	20,87%	21,02%
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	2,64%	3,19%	4,02%

In order to identity the basic component of the Markov analysis, the process of operating as employee in a certain sector is seen as a random selection process determined by the various influencing variables: sector attractiveness, considered in relation with average wage, stability of the job position, education background and detained skills, career's prospective, etc.

TABLE 6 - THE INCIPIENT CALCULATION FOR THE 2009-2010 PERIOD - ROMANIA

	Code of state	Year 2009	Year 2010	Delta	Positive Delta
Agriculture, forestry and fishing	State 1	29,09%	30,09%	1,00%	1,00%
Industry (except construction)	State 2	22,16%	21,04%	-1,13%	0,00%
Construction	State 3	7,85%	7,63%	-0,22%	0,00%
Wholesale and retail trade, transport, accommodation and food service activities	State 4	19,22%	19,02%	-0,19%	0,00%
Information and communication	State 5	1,33%	1,36%	0,03%	0,03%
Financial and insurance activities	State 6	1,32%	1,43%	0,11%	0,11%
Real estate activities	State 7	0,17%	0,21%	0,04%	0,04%
Professional, scientific and technical activities; administrative and support service activities	State 8	3,22%	3,39%	0,16%	0,16%
Public administration, defense, education, human health and social work activities	State 9	13,75%	13,63%	-0,12%	0,00%
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	State 10	1,88%	2,21%	0,33%	0,33%
Total					1,66%

Following the computations as written in equations 1 to 4, for Romania and each euro-region, two partial transition matrices were computing: PTM2010/2009, PTM2009/2008 and the final transition matrix.

TABLE 7 - THE PARTIAL TRANSITION MATRIX FOR 2009-2010 - ROMANIA

States	1	2	3	4	5	6	7	8	9	10
1	0.2909									
2	0.0067	0.2104			0.0002	0.0007	0.0003	0.0011		0.0022
3	0.0013		0.0763		0.0000	0.0001	0.0001	0.0002		0.0004
4	0.0012			0.1902	0.0000	0.0001	0.0000	0.0002		0.0004
5					0.0133					
6						0.0132				
7							0.0017			
8								0.0322		
9	0.0007				0.0000	0.0001	0.0000	0.0001	0.1363	0.0002
10										0.0188

TABLE 8 - THE FINAL TRANSITION MATRIX FOR 2009-2010 - ROMANIA

States	1	2	3	4	5	6	7	8	9	10
1	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0224	0.9438	0.0000	0.0055	0.0017	0.0044	0.0007	0.0062	0.0090	0.0062
3	0.0107	0.0000	0.9770	0.0015	0.0006	0.0017	0.0004	0.0024	0.0025	0.0032
4	0.0030	0.0000	0.0000	0.9949	0.0001	0.0003	0.0001	0.0005	0.0000	0.0010
5	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
9	0.0026	0.0000	0.0000	0.0000	0.0001	0.0003	0.0001	0.0004	0.9957	0.0009
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

By involving the Markov Chains, it is aimed to estimate the vector $S_t = \{p_1(t), p_2(t),..., p_n(t)\}$ where the probability $p_i(t)$ is the fraction expected from the set of all elements in the state i at period t. By following the model assumptions all these elements should sum up to 1 from each time period, for all i=1,2,…n, at time t.

Markov chain method involves calculating the vector according to the relationship:

$$S_t = S_{t-1} \cdot P_{t/t-1} \qquad \text{(Eq. 6)}$$

Theoretical and Empirical Researches in Urban Management
Volume 6 Issue 4 / November 2011

The eq. 6 is formulating the following reasoning: current condition of the system expressed by S_t (the vector of possible states at time t) depends only on previous state S_{t-1} (vector of states in the past) and the switching behavior described by the transition matrix $P_{t/t-1}$; using several times the eq. 6, the forecast may be performed obtaining the estimates on the short time.

TABLE 9 - FORECASTED VALUE OF POPULATION EMPLOYED BY VARIOUS TYPES OF ECONOMIC ACTIVITY - ROMANIA

Year	State 1	State 2	State 3	State 4	State 5	State 6	State 7	State 8	State 9	State 10
2010	30.09%	21.04%	7.63%	19.02%	1.36%	1.43%	0.21%	3.39%	13.63%	2.21%
2011	30.73%	19.86%	7.45%	19.05%	1.41%	1.55%	0.23%	3.55%	13.78%	2.40%
2012	31.35%	18.74%	7.28%	19.08%	1.45%	1.66%	0.25%	3.71%	13.92%	2.57%
2013	31.95%	17.69%	7.11%	19.09%	1.49%	1.76%	0.27%	3.85%	14.05%	2.74%
2014	32.51%	16.69%	6.95%	19.10%	1.52%	1.86%	0.29%	4.00%	14.16%	2.91%
2015	33.06%	15.76%	6.79%	19.11%	1.56%	1.96%	0.31%	4.13%	14.27%	3.07%

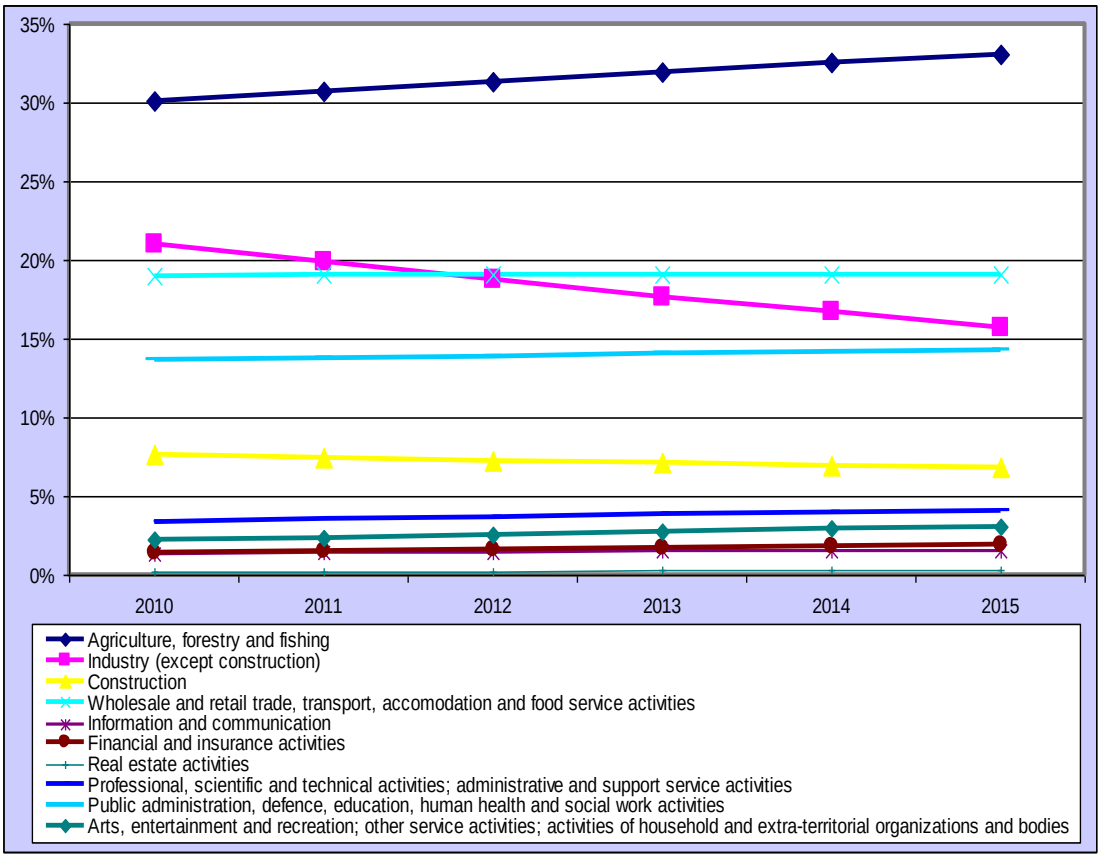

FIGURE 1 - REPRESENTATION ON FORECASTING EMPLOYMENT BY VARIOUS TYPES IN ROMANIA – 2011-2015

TABLE 10 - FORECASTED VALUE OF POPULATION EMPLOYED BY VARIOUS TYPES OF ECONOMIC ACTIVITY – BUCHAREST-ILFOV

Year	State 1	State 2	State 3	State 4	State 5	State 6	State 7	State 8	State 9	State 10
2010	1.01%	14.10%	9.48%	31.65%	5.18%	4.15%	0.72%	8.68%	21.02%	4.02%
2011	0.89%	13.37%	8.76%	30.87%	5.51%	4.77%	0.82%	8.79%	21.56%	4.66%
2012	0.78%	12.68%	8.10%	30.11%	5.83%	5.35%	0.91%	8.89%	22.08%	5.27%
2013	0.69%	12.03%	7.48%	29.37%	6.13%	5.90%	0.99%	8.98%	22.56%	5.85%
2014	0.62%	11.41%	6.91%	28.65%	6.42%	6.43%	1.07%	9.07%	23.01%	6.40%
2015	0.55%	10.83%	6.39%	27.95%	6.69%	6.93%	1.15%	9.14%	23.44%	6.93%

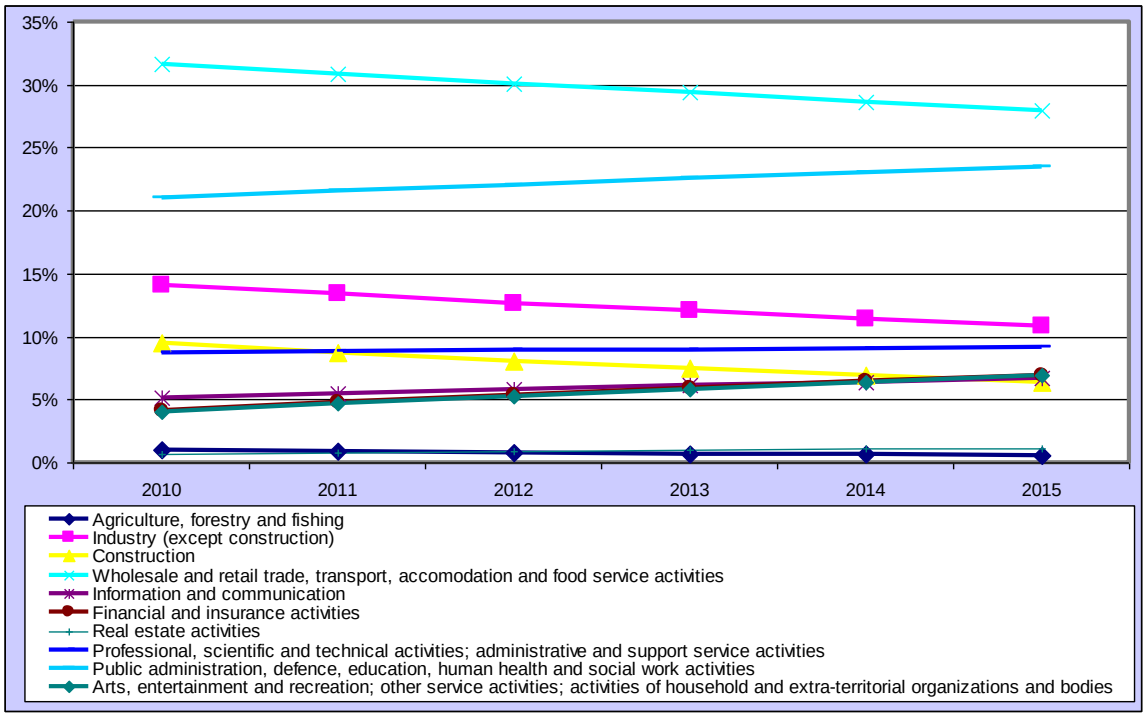

FIGURE 2 - REPRESENTATION ON FORECASTING EMPLOYMENT BY VARIOUS TYPES IN REGION BUCHAREST – ILFOV – 2011-2015

In order to infer on the convergent trends in the various regions, the dispersion of the distances from the annual averages of the structural weights will be computed as follows: $z_{it} = \frac{x_{it}}{\overline{x_t}}$ with meeting the condition that: $\frac{\sum_i z_{it}}{n} = 1$. The dispersion may indicate if is constantly decreasing that the convergence process is happening during the time period t=1,…T.

Similarly relevant could be the evolution of standard deviation indicator for the structural changes in the proportions of the employment – the forecasted values for the 2010-2015 period.

TABLE 11 - THE STANDARD DEVIATION FOR ROMANIA AND BUCHAREST-ILFOV REGION

Year	Standard deviation Romania	Standard deviation Bucharest
2010	0.104026	0.098262
2011	0.103817	0.095864
2012	0.10382	0.093775
2013	0.104005	0.09197
2014	0.104343	0.090422
2015	0.104809	0.089106

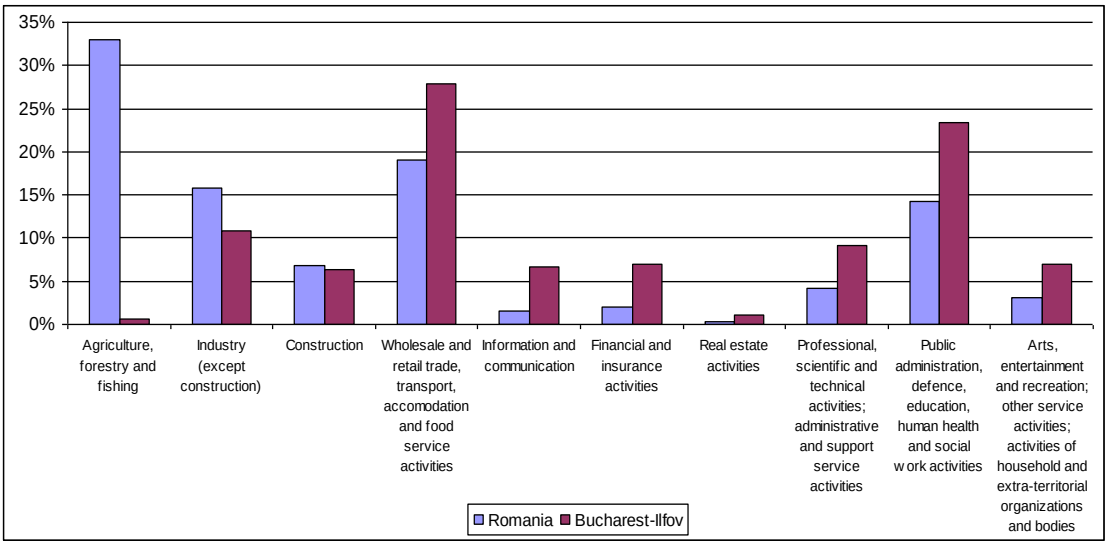

FIGURE 3 - THE ESTIMATED STRUCTURE FOR YEAR 2015 IN EMPLOYMENT ACTIVITY

As it is seen from the previous calculation, there appear to be a divergent evolution of the employment patters among the different territorial areas: whereas, at national level, the variance is almost steady on the forecast horizon, keeping high percentages in the Agriculture, forestry and fishing sector, for the Bucharest-Ilfov area the convergence process is strengthening, in the directions of Wholesale and retail trade, transport, accommodation and food service activities sector.

REFERENCES

van Assche, J., Herwig Reynaert, (2009) Harnessing Knowledge Through Urban Indicators: Measuring Quality Of Life In Flemish Cities, City Futures in a Globalizing World: International Conference on Globalism and Urban Change

Borghi, A., (2010) A new "Basket" for Urban Quality Indicators, October 15, 2010; http://welldesignedandbuilt.com/2010/10/15/a-new-basket-for-urban-quality-indicators/

Hersh, M., Hamburg, I., (2006). Mathematical Modelling for Sustainable Development, Springer Verlag, 2006

Lazăr, C., Lazăr, M., (2010) Number and Structure of Romania's Employed Population - Evolutions and Perspectives at National and Regional Level, Revista Română de Statistică, nr. 8/2011

Lim, L.Y., Yuen, B., Löw, C., (1999) Urban quality of life: critical issues and options, National University of Singapore. School of Building and Real Estate, © Copyright 2001-07 National University of Singapore